

LinksPlatform's Platform.Data.Doublets Class Library

1.1 ./csharp/Platform.Data.Doublets/CriterionMatchers/TargetMatcher.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.CriterionMatchers
8 {
9     public class TargetMatcher<TLink> : LinksOperatorBase<TLink>, ICriterionMatcher<TLink>
10     {
11         private static readonly EqualityComparer<TLink> _equalityComparer =
12             ↳ EqualityComparer<TLink>.Default;
13
14         private readonly TLink _targetToMatch;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public TargetMatcher(ILinks<TLink> links, TLink targetToMatch) : base(links) =>
18             ↳ _targetToMatch = targetToMatch;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public bool IsMatched(TLink link) => _equalityComparer.Equals(_links.GetTarget(link),
22             ↳ _targetToMatch);
23     }
24 }
```

1.2 ./csharp/Platform.Data.Doublets/Decorators/LinksCascadeUniquenessAndUsagesResolver.cs

```
1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Decorators
6 {
7     public class LinksCascadeUniquenessAndUsagesResolver<TLink> : LinksUniquenessResolver<TLink>
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10         public LinksCascadeUniquenessAndUsagesResolver(ILinks<TLink> links) : base(links) { }
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         protected override TLink ResolveAddressChangeConflict(TLink oldLinkAddress, TLink
14             ↳ newLinkAddress)
15         {
16             // Use Facade (the last decorator) to ensure recursion working correctly
17             _facade.MergeUsages(oldLinkAddress, newLinkAddress);
18             return base.ResolveAddressChangeConflict(oldLinkAddress, newLinkAddress);
19         }
20     }
21 }
```

1.3 ./csharp/Platform.Data.Doublets/Decorators/LinksCascadeUsagesResolver.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.Decorators
7 {
8     /// <remarks>
9     /// <para>Must be used in conjunction with NonNullContentsLinkDeletionResolver.</para>
10     /// <para>Должен использоваться вместе с NonNullContentsLinkDeletionResolver.</para>
11     /// </remarks>
12     public class LinksCascadeUsagesResolver<TLink> : LinksDecoratorBase<TLink>
13     {
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public LinksCascadeUsagesResolver(ILinks<TLink> links) : base(links) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public override void Delete(ICollection<TLink> restrictions)
19         {
20             var linkIndex = restrictions[_constants.IndexPart];
21             // Use Facade (the last decorator) to ensure recursion working correctly
22             _facade.DeleteAllUsages(linkIndex);
23             _links.Delete(linkIndex);
24         }
25     }
26 }
```

1.4 ./csharp/Platform.Data.Doublets/Decorators/LinksDecoratorBase.cs

```
1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Decorators
8 {
9     public abstract class LinksDecoratorBase<TLink> : LinksOperatorBase<TLink>, ILinks<TLink>
10    {
11        protected readonly LinksConstants<TLink> _constants;
12
13        public LinksConstants<TLink> Constants
14        {
15            [MethodImpl(MethodImplOptions.AggressiveInlining)]
16            get => _constants;
17        }
18
19        protected ILinks<TLink> _facade;
20
21        public ILinks<TLink> Facade
22        {
23            [MethodImpl(MethodImplOptions.AggressiveInlining)]
24            get => _facade;
25            [MethodImpl(MethodImplOptions.AggressiveInlining)]
26            set
27            {
28                _facade = value;
29                if (_links is LinksDecoratorBase<TLink> decorator)
30                {
31                    decorator.Facade = value;
32                }
33            }
34        }
35
36        [MethodImpl(MethodImplOptions.AggressiveInlining)]
37        protected LinksDecoratorBase(ILinks<TLink> links) : base(links)
38        {
39            _constants = links.Constants;
40            Facade = this;
41        }
42
43        [MethodImpl(MethodImplOptions.AggressiveInlining)]
44        public virtual TLink Count(IList<TLink> restrictions) => _links.Count(restrictions);
45
46        [MethodImpl(MethodImplOptions.AggressiveInlining)]
47        public virtual TLink Each(Func<IList<TLink>, TLink> handler, IList<TLink> restrictions)
48            => _links.Each(handler, restrictions);
49
50        [MethodImpl(MethodImplOptions.AggressiveInlining)]
51        public virtual TLink Create(IList<TLink> restrictions) => _links.Create(restrictions);
52
53        [MethodImpl(MethodImplOptions.AggressiveInlining)]
54        public virtual TLink Update(IList<TLink> restrictions, IList<TLink> substitution) =>
55            _links.Update(restrictions, substitution);
56
57        [MethodImpl(MethodImplOptions.AggressiveInlining)]
58        public virtual void Delete(IList<TLink> restrictions) => _links.Delete(restrictions);
59    }
60 }
```

1.5 ./csharp/Platform.Data.Doublets/Decorators/LinksDisposableDecoratorBase.cs

```
1 using System.Runtime.CompilerServices;
2 using Platform.Disposables;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5 #pragma warning disable CA1063 // Implement IDisposable Correctly
6
7 namespace Platform.Data.Doublets.Decorators
8 {
9     public abstract class LinksDisposableDecoratorBase<TLink> : LinksDecoratorBase<TLink>,
10        ILinks<TLink>, System.IDisposable
11    {
12        protected class DisposableWithMultipleCallsAllowed : Disposable
13        {
14            [MethodImpl(MethodImplOptions.AggressiveInlining)]
15            public DisposableWithMultipleCallsAllowed(Disposal disposal) : base(disposal) { }
16
17            protected override bool AllowMultipleDisposeCalls
18            {
19                get { return true; }
20            }
21        }
22    }
23 }
```

```

17     {
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         get => true;
20     }
21 }
22
23 protected readonly DisposableWithMultipleCallsAllowed Disposable;
24
25 [MethodImpl(MethodImplOptions.AggressiveInlining)]
26 protected LinksDisposableDecoratorBase(ILinks<TLink> links) : base(links) => Disposable
27     => = new DisposableWithMultipleCallsAllowed(Dispose);
28
29 [MethodImpl(MethodImplOptions.AggressiveInlining)]
30 ~LinksDisposableDecoratorBase() => Disposable.Destruct();
31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 public void Dispose() => Disposable.Dispose();
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 protected virtual void Dispose(bool manual, bool wasDisposed)
37 {
38     if (!wasDisposed)
39     {
40         _links.DisposeIfPossible();
41     }
42 }
43 }

```

1.6 ./csharp/Platform.Data.Doublets/Decorators/LinksInnerReferenceExistenceValidator.cs

```

1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Decorators
8 {
9     // TODO: Make LinksExternalReferenceValidator. A layer that checks each link to exist or to
10     // be external (hybrid link's raw number).
11     public class LinksInnerReferenceExistenceValidator<TLink> : LinksDecoratorBase<TLink>
12     {
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public LinksInnerReferenceExistenceValidator(ILinks<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public override TLink Each(Func<IList<TLink>, TLink> handler, IList<TLink> restrictions)
18         {
19             var links = _links;
20             links.EnsureInnerReferenceExists(restrictions, nameof(restrictions));
21             return links.Each(handler, restrictions);
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public override TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
26         {
27             // TODO: Possible values: null, ExistentLink or NonExistentHybrid(ExternalReference)
28             var links = _links;
29             links.EnsureInnerReferenceExists(restrictions, nameof(restrictions));
30             links.EnsureInnerReferenceExists(substitution, nameof(substitution));
31             return links.Update(restrictions, substitution);
32         }
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public override void Delete(IList<TLink> restrictions)
36         {
37             var link = restrictions[_constants.IndexPart];
38             var links = _links;
39             links.EnsureLinkExists(link, nameof(link));
40             links.Delete(link);
41         }
42     }
43 }

```

1.7 ./csharp/Platform.Data.Doublets/Decorators/LinksItselfConstantToSelfReferenceResolver.cs

```

1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4

```

```

5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Decorators
8  {
9      public class LinksItselfConstantToSelfReferenceResolver<TLink> : LinksDecoratorBase<TLink>
10     {
11         private static readonly EqualityComparer<TLink> _equalityComparer =
12             ↪ EqualityComparer<TLink>.Default;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public LinksItselfConstantToSelfReferenceResolver(ILinks<TLink> links) : base(links) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public override TLink Each(Func<IList<TLink>, TLink> handler, IList<TLink> restrictions)
19         {
20             var constants = _constants;
21             var itselfConstant = constants.Itself;
22             if (!_equalityComparer.Equals(constants.Any, itselfConstant) &&
23                 ↪ restrictions.Contains(itselfConstant))
24             {
25                 // Itself constant is not supported for Each method right now, skipping execution
26                 return constants.Continue;
27             }
28             return _links.Each(handler, restrictions);
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public override TLink Update(IList<TLink> restrictions, IList<TLink> substitution) =>
32             ↪ _links.Update(restrictions, _links.ResolveConstantAsSelfReference(_constants.Itself,
33                 ↪ restrictions, substitution));
34     }
35 }

```

1.8 ./csharp/Platform.Data.Doublets.Decorators/LinksNonExistentDependenciesCreator.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.Decorators
7  {
8      /// <remarks>
9      /// Not practical if newSource and newTarget are too big.
10     /// To be able to use practical version we should allow to create link at any specific
11     ↪ location inside ResizableDirectMemoryLinks.
12     /// This in turn will require to implement not a list of empty links, but a list of ranges
13     ↪ to store it more efficiently.
14     /// </remarks>
15     public class LinksNonExistentDependenciesCreator<TLink> : LinksDecoratorBase<TLink>
16     {
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public LinksNonExistentDependenciesCreator(ILinks<TLink> links) : base(links) { }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public override TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
22         {
23             var constants = _constants;
24             var links = _links;
25             links.EnsureCreated(substitution[constants.SourcePart],
26                 ↪ substitution[constants.TargetPart]);
27             return links.Update(restrictions, substitution);
28         }
29     }
30 }

```

1.9 ./csharp/Platform.Data.Doublets.Decorators/LinksNullConstantToSelfReferenceResolver.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.Decorators
7  {
8      public class LinksNullConstantToSelfReferenceResolver<TLink> : LinksDecoratorBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksNullConstantToSelfReferenceResolver(ILinks<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

14         public override TLink Create(ICollection<TLink> restrictions) => _links.CreatePoint();
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public override TLink Update(ICollection<TLink> restrictions, ICollection<TLink> substitution) =>
18             ↪ _links.Update(restrictions, _links.ResolveConstantAsSelfReference(_constants.Null,
19             ↪ restrictions, substitution));
18     }
19 }

```

1.10 ./csharp/Platform.Data.Doublets/Decorators/LinksUniquenessResolver.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.Decorators
7 {
8     public class LinksUniquenessResolver<TLink> : LinksDecoratorBase<TLink>
9     {
10         private static readonly EqualityComparer<TLink> _equalityComparer =
11             ↪ EqualityComparer<TLink>.Default;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public LinksUniquenessResolver(ICollection<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public override TLink Update(ICollection<TLink> restrictions, ICollection<TLink> substitution)
18         {
19             var constants = _constants;
20             var links = _links;
21             var newLinkAddress = links.SearchOrDefault(substitution[constants.SourcePart],
22             ↪ substitution[constants.TargetPart]);
23             if (_equalityComparer.Equals(newLinkAddress, default))
24             {
25                 return links.Update(restrictions, substitution);
26             }
27             return ResolveAddressChangeConflict(restrictions[constants.IndexPart],
28             ↪ newLinkAddress);
29         }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected virtual TLink ResolveAddressChangeConflict(TLink oldLinkAddress, TLink
33             ↪ newLinkAddress)
34         {
35             if (!_equalityComparer.Equals(oldLinkAddress, newLinkAddress) &&
36             ↪ _links.Exists(oldLinkAddress))
37             {
38                 _facade.Delete(oldLinkAddress);
39             }
40             return newLinkAddress;
41         }
42     }
43 }

```

1.11 ./csharp/Platform.Data.Doublets/Decorators/LinksUniquenessValidator.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.Decorators
7 {
8     public class LinksUniquenessValidator<TLink> : LinksDecoratorBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksUniquenessValidator(ICollection<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public override TLink Update(ICollection<TLink> restrictions, ICollection<TLink> substitution)
15         {
16             var links = _links;
17             var constants = _constants;
18             links.EnsureDoesNotExists(substitution[constants.SourcePart],
19             ↪ substitution[constants.TargetPart]);
20             return links.Update(restrictions, substitution);
21         }
22     }
23 }

```

1.12 ./csharp/Platform.Data.Doublets/Decorators/LinksUsagesValidator.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.Decorators
7 {
8     public class LinksUsagesValidator<TLink> : LinksDecoratorBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksUsagesValidator(ILinks<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public override TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
15         {
16             var links = _links;
17             links.EnsureNoUsages(restrictions[_constants.IndexPart]);
18             return links.Update(restrictions, substitution);
19         }
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public override void Delete(IList<TLink> restrictions)
23         {
24             var link = restrictions[_constants.IndexPart];
25             var links = _links;
26             links.EnsureNoUsages(link);
27             links.Delete(link);
28         }
29     }
30 }
```

1.13 ./csharp/Platform.Data.Doublets/Decorators/NonNullContentsLinkDeletionResolver.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.Decorators
7 {
8     public class NonNullContentsLinkDeletionResolver<TLink> : LinksDecoratorBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public NonNullContentsLinkDeletionResolver(ILinks<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public override void Delete(IList<TLink> restrictions)
15         {
16             var linkIndex = restrictions[_constants.IndexPart];
17             var links = _links;
18             links.EnforceResetValues(linkIndex);
19             links.Delete(linkIndex);
20         }
21     }
22 }
```

1.14 ./csharp/Platform.Data.Doublets/Decorators/UInt64Links.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.Decorators
7 {
8     /// <summary>
9     /// <para>Represents a combined decorator that implements the basic logic for interacting
10     ///   with the links storage for links with addresses represented as <see cref="System.UInt64">
11     ///   </para>
12     /// <para>Представляет комбинированный декоратор, реализующий основную логику по
13     ///   взаимодействию с хранилищем связей, для связей с адресами представленными в виде <see
14     ///   cref="System.UInt64"/>.</para>
15     /// </summary>
16     /// <remarks>
17     /// Возможные оптимизации:
18     /// Объединение в одном поле Source и Target с уменьшением до 32 бит.
19     /// + меньше объём БД
20     /// - меньше производительность
21     /// - больше ограничение на количество связей в БД)
22     /// Ленивое хранение размеров поддеревьев (расчитываемое по мере использования БД)
```

```

19  ///      + меньше объём БД
20  ///      - больше сложность
21  ///
22  /// Текущее теоретическое ограничение на индекс связи, из-за использования 5 бит в размере
   ↳ поддеревьев для AVL баланса и флагов нитей: 2 в степени(64 минус 5 равно 59 ) равно 576
   ↳ 460 752 303 423 488
23  /// Желательно реализовать поддержку переключения между деревьями и битовыми индексами
   ↳ (битовыми строками) - вариант матрицы (выстраиваемой лениво).
24  ///
25  /// Решить отключать ли проверки при компиляции под Release. Т.е. исключения будут
   ↳ выбрасываться только при #if DEBUG
26  /// </remarks>
27  public class UInt64Links : LinksDisposableDecoratorBase<ulong>
28  {
29      [MethodImpl(MethodImplOptions.AggressiveInlining)]
30      public UInt64Links(ILinks<ulong> links) : base(links) { }
31
32      [MethodImpl(MethodImplOptions.AggressiveInlining)]
33      public override ulong Create(IList<ulong> restrictions) => _links.CreatePoint();
34
35      [MethodImpl(MethodImplOptions.AggressiveInlining)]
36      public override ulong Update(IList<ulong> restrictions, IList<ulong> substitution)
37      {
38          var constants = _constants;
39          var indexPartConstant = constants.IndexPart;
40          var sourcePartConstant = constants.SourcePart;
41          var targetPartConstant = constants.TargetPart;
42          var nullConstant = constants.Null;
43          var itselfConstant = constants.Itself;
44          var existedLink = nullConstant;
45          var updatedLink = restrictions[indexPartConstant];
46          var newSource = substitution[sourcePartConstant];
47          var newTarget = substitution[targetPartConstant];
48          var links = _links;
49          if (newSource != itselfConstant && newTarget != itselfConstant)
50          {
51              existedLink = links.SearchOrDefault(newSource, newTarget);
52          }
53          if (existedLink == nullConstant)
54          {
55              var before = links.GetLink(updatedLink);
56              if (before[sourcePartConstant] != newSource || before[targetPartConstant] !=
   ↳ newTarget)
57              {
58                  links.Update(updatedLink, newSource == itselfConstant ? updatedLink :
   ↳ newSource,
59                                  newTarget == itselfConstant ? updatedLink :
   ↳ newTarget);
60              }
61              return updatedLink;
62          }
63          else
64          {
65              return _facade.MergeAndDelete(updatedLink, existedLink);
66          }
67      }
68
69      [MethodImpl(MethodImplOptions.AggressiveInlining)]
70      public override void Delete(IList<ulong> restrictions)
71      {
72          var linkIndex = restrictions[_constants.IndexPart];
73          var links = _links;
74          links.EnforceResetValues(linkIndex);
75          _facade.DeleteAllUsages(linkIndex);
76          links.Delete(linkIndex);
77      }
78  }
79  }

```

1.15 ./csharp/Platform.Data.Doublets/Decorators/UniLinks.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Linq;
4  using Platform.Collections;
5  using Platform.Collections.Lists;
6  using Platform.Data.Universal;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9

```

```

10 namespace Platform.Data.Doublets.Decorators
11 {
12     /// <remarks>
13     /// What does empty pattern (for condition or substitution) mean? Nothing or Everything?
14     /// Now we go with nothing. And nothing is something one, but empty, and cannot be changed
15     /// ↪ by itself. But can cause creation (update from nothing) or deletion (update to nothing).
16     ///
17     /// TODO: Decide to change to IDoubletLinks or not to change. (Better to create
18     /// ↪ DefaultUniLinksBase, that contains logic itself and can be implemented using both
19     /// ↪ IDoubletLinks and ILinks.)
20     /// </remarks>
21     internal class UniLinks<TLink> : LinksDecoratorBase<TLink>, IUniLinks<TLink>
22     {
23         private static readonly EqualityComparer<TLink> _equalityComparer =
24             ↪ EqualityComparer<TLink>.Default;
25
26         public UniLinks(ILinks<TLink> links) : base(links) { }
27
28         private struct Transition
29         {
30             public IList<TLink> Before;
31             public IList<TLink> After;
32
33             public Transition(IList<TLink> before, IList<TLink> after)
34             {
35                 Before = before;
36                 After = after;
37             }
38         }
39
40         //public static readonly TLink NullConstant = Use<LinksConstants<TLink>>.Single.Null;
41         //public static readonly IReadOnlyList<TLink> NullLink = new
42         ↪ ReadOnlyCollection<TLink>(new List<TLink> { NullConstant, NullConstant, NullConstant
43         ↪ });
44
45         // TODO: Подумать о том, как реализовать древовидный Restriction и Substitution
46         ↪ (Links-Expression)
47         public TLink Trigger(IList<TLink> restriction, Func<IList<TLink>, IList<TLink>, TLink>
48         ↪ matchedHandler, IList<TLink> substitution, Func<IList<TLink>, IList<TLink>, TLink>
49         ↪ substitutedHandler)
50         {
51             ///List<Transition> transitions = null;
52             ///if (!restriction.IsNullOrEmpty())
53             ///{
54             ///    // Есть причина делать проход (чтение)
55             ///    if (matchedHandler != null)
56             ///    {
57             ///        if (!substitution.IsNullOrEmpty())
58             ///        {
59             ///            // restriction => { 0, 0, 0 } | { 0 } // Create
60             ///            // substitution => { itself, 0, 0 } | { itself, itself, itself } //
61             ↪ Create / Update
62             ///            // substitution => { 0, 0, 0 } | { 0 } // Delete
63             ///            transitions = new List<Transition>();
64             ///            if (Equals(substitution[Constants.IndexPart], Constants.Null))
65             ///            {
66             ///                // If index is Null, that means we always ignore every other
67             ↪ value (they are also Null by definition)
68             ///                var matchDecision = matchedHandler(, NullLink);
69             ///                if (Equals(matchDecision, Constants.Break))
70             ///                    return false;
71             ///                if (!Equals(matchDecision, Constants.Skip))
72             ///                    transitions.Add(new Transition(matchedLink, newValue));
73             ///            }
74             ///            else
75             ///            {
76             ///                Func<T, bool> handler;
77             ///                handler = link =>
78             ///                {
79             ///                    var matchedLink = Memory.GetLinkValue(link);
80             ///                    var newValue = Memory.GetLinkValue(link);
81             ///                    newValue[Constants.IndexPart] = Constants.Itself;
82             ///                    newValue[Constants.SourcePart] =
83             ↪ Equals(substitution[Constants.SourcePart], Constants.Itself) ?
84             ↪ matchedLink[Constants.IndexPart] : substitution[Constants.SourcePart];
85             ///                    newValue[Constants.TargetPart] =
86             ↪ Equals(substitution[Constants.TargetPart], Constants.Itself) ?
87             ↪ matchedLink[Constants.IndexPart] : substitution[Constants.TargetPart];

```



```

73         var matchDecision = matchedHandler(matchedLink, newValue);
74         if (Equals(matchDecision, Constants.Break))
75             return false;
76         if (!Equals(matchDecision, Constants.Skip))
77             transitions.Add(new Transition(matchedLink, newValue));
78         return true;
79     };
80     if (!Memory.Each(handler, restriction))
81         return Constants.Break;
82     }
83     }
84     else
85     {
86         Func<T, bool> handler = link =>
87         {
88             var matchedLink = Memory.GetLinkValue(link);
89             var matchDecision = matchedHandler(matchedLink, matchedLink);
90             return !Equals(matchDecision, Constants.Break);
91         };
92         if (!Memory.Each(handler, restriction))
93             return Constants.Break;
94     }
95     }
96     else
97     {
98         if (substitution != null)
99         {
100             transitions = new List<IList<T>>();
101             Func<T, bool> handler = link =>
102             {
103                 var matchedLink = Memory.GetLinkValue(link);
104                 transitions.Add(matchedLink);
105                 return true;
106             };
107             if (!Memory.Each(handler, restriction))
108                 return Constants.Break;
109         }
110         else
111         {
112             return Constants.Continue;
113         }
114     }
115 }
116 if (substitution != null)
117 {
118     // Есть причина делать замену (запись)
119     if (substitutedHandler != null)
120     {
121     }
122     else
123     {
124     }
125 }
126 return Constants.Continue;
127
128 //if (restriction.IsNullOrEmpty()) // Create
129 //{
130 //    substitution[Constants.IndexPart] = Memory.AllocateLink();
131 //    Memory.SetLinkValue(substitution);
132 //}
133 //else if (substitution.IsNullOrEmpty()) // Delete
134 //{
135 //    Memory.FreeLink(restriction[Constants.IndexPart]);
136 //}
137 //else if (restriction.EqualTo(substitution)) // Read or ("repeat" the state) // Each
138 //{
139 //    // No need to collect links to list
140 //    // Skip == Continue
141 //    // No need to check substitutedHandler
142 //    if (!Memory.Each(link => !Equals(matchedHandler(Memory.GetLinkValue(link)),
143 //        ↪ Constants.Break), restriction))
144 //        return Constants.Break;
145 //}
146 //else // Update
147 //{
148 //    //List<IList<T>> matchedLinks = null;
149 //    if (matchedHandler != null)
150 //    {

```

```

150         // matchedLinks = new List<ILink<T>>>();
151         // Func<T, bool> handler = link =>
152         // {
153         //     var matchedLink = Memory.GetLinkValue(link);
154         //     var matchDecision = matchedHandler(matchedLink);
155         //     if (Equals(matchDecision, Constants.Break))
156         //         return false;
157         //     if (!Equals(matchDecision, Constants.Skip))
158         //         matchedLinks.Add(matchedLink);
159         //     return true;
160         // };
161         // if (!Memory.Each(handler, restriction))
162         //     return Constants.Break;
163     // }
164     // if (!matchedLinks.IsNullOrEmpty())
165     // {
166     //     var totalMatchedLinks = matchedLinks.Count;
167     //     for (var i = 0; i < totalMatchedLinks; i++)
168     //     {
169     //         var matchedLink = matchedLinks[i];
170     //         if (substitutedHandler != null)
171     //         {
172     //             var newValue = new List<T>(); // TODO: Prepare value to update here
173     //             // TODO: Decide is it actually needed to use Before and After
174     //             ↪ substitution handling.
175     //             var substitutedDecision = substitutedHandler(matchedLink,
176     //             ↪ newValue);
177     //             if (Equals(substitutedDecision, Constants.Break))
178     //                 return Constants.Break;
179     //             if (Equals(substitutedDecision, Constants.Continue))
180     //             {
181     //                 // Actual update here
182     //                 Memory.SetLinkValue(newValue);
183     //             }
184     //             if (Equals(substitutedDecision, Constants.Skip))
185     //             {
186     //                 // Cancel the update. TODO: decide use separate Cancel
187     //                 ↪ constant or Skip is enough?
188     //             }
189     //         }
190     //     }
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1000    // }

```

```

220     {
221         after = _links.GetLink(substitution[0]);
222     }
223     else if (substitution.Count == 3)
224     {
225         //Links.Create(after);
226     }
227     else
228     {
229         throw new NotSupportedException();
230     }
231     if (matchHandler != null)
232     {
233         return substitutionHandler(before, after);
234     }
235     return constants.Continue;
236 }
237 else if (!patternOrCondition.IsNullOrEmpty()) // Deletion
238 {
239     if (patternOrCondition.Count == 1)
240     {
241         var linkToDelete = patternOrCondition[0];
242         var before = _links.GetLink(linkToDelete);
243         if (matchHandler != null && _equalityComparer.Equals(matchHandler(before),
244             ↪ constants.Break))
245         {
246             return constants.Break;
247         }
248         var after = Array.Empty<TLink>();
249         _links.Update(linkToDelete, constants.Null, constants.Null);
250         _links.Delete(linkToDelete);
251         if (matchHandler != null)
252         {
253             return substitutionHandler(before, after);
254         }
255         return constants.Continue;
256     }
257     else
258     {
259         throw new NotSupportedException();
260     }
261 }
262 else // Replace / Update
263 {
264     if (patternOrCondition.Count == 1) //-V3125
265     {
266         var linkToUpdate = patternOrCondition[0];
267         var before = _links.GetLink(linkToUpdate);
268         if (matchHandler != null && _equalityComparer.Equals(matchHandler(before),
269             ↪ constants.Break))
270         {
271             return constants.Break;
272         }
273         var after = (IList<TLink>)substitution.ToArray(); //-V3125
274         if (_equalityComparer.Equals(after[0], default))
275         {
276             after[0] = linkToUpdate;
277         }
278         if (substitution.Count == 1)
279         {
280             if (!_equalityComparer.Equals(substitution[0], linkToUpdate))
281             {
282                 after = _links.GetLink(substitution[0]);
283                 _links.Update(linkToUpdate, constants.Null, constants.Null);
284                 _links.Delete(linkToUpdate);
285             }
286         }
287         else if (substitution.Count == 3)
288         {
289             //Links.Update(after);
290         }
291         else
292         {
293             throw new NotSupportedException();
294         }
295         if (matchHandler != null)
296         {
297             return substitutionHandler(before, after);
298         }
299     }
300 }

```

```

    }
    return constants.Continue;
}
else
{
    throw new NotSupportedException();
}
}

}

/// <remarks>
/// IList[IList[IList[T]]]
/// |           |           |
/// |           |-----|
/// |           link      |
/// |-----|
/// | change             |
/// |-----|
/// | changes            |
/// </remarks>
public IList<IList<IList<TLink>>> Trigger(IList<TLink> condition, IList<TLink>
↪ substitution)
{
    var changes = new List<IList<IList<TLink>>>>();
    var @continue = _constants.Continue;
    Trigger(condition, AlwaysContinue, substitution, (before, after) =>
    {
        var change = new[] { before, after };
        changes.Add(change);
        return @continue;
    });
    return changes;
}

private TLink AlwaysContinue(IList<TLink> linkToMatch) => _constants.Continue;
```

1.16 ./csharp/Platform.Data.Doublets/Doublet.cs

```

1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets
8 {
9     public struct Doublet<T> : IEquatable<Doublet<T>>
10     {
11         private static readonly EqualityComparer<T> _equalityComparer =
12             ↳ EqualityComparer<T>.Default;
13
14         public readonly T Source;
15
16         public readonly T Target;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public Doublet(T source, T target)
20         {
21             Source = source;
22             Target = target;
23         }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public override string ToString() => $"{Source}->{Target}";
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public bool Equals(Doublet<T> other) => _equalityComparer.Equals(Source, other.Source)
30             ↳ && _equalityComparer.Equals(Target, other.Target);
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public override bool Equals(object obj) => obj is Doublet<T> doublet ?
34             ↳ base.Equals(doublet) : false;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public override int GetHashCode() => (Source, Target).GetHashCode();
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         public static bool operator ==(Doublet<T> left, Doublet<T> right) => left.Equals(right);
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public static bool operator !=(Doublet<T> left, Doublet<T> right) => !left.Equals(right);
44     }
45 }

```

```

39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         public static bool operator !=(Doublet<T> left, Doublet<T> right) => !(left == right);
41     }
42 }

```

1.17 ./csharp/Platform.Data.Doublets/DoubletComparer.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
7  {
8      /// <remarks>
9      /// TODO: Может стоит попробовать ref во всех методах (IRefEqualityComparer)
10     /// 2x faster with comparer
11     /// </remarks>
12     public class DoubletComparer<T> : IEqualityComparer<Doublet<T>>
13     {
14         public static readonly DoubletComparer<T> Default = new DoubletComparer<T>();
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public bool Equals(Doublet<T> x, Doublet<T> y) => x.Equals(y);
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public int GetHashCode(Doublet<T> obj) => obj.GetHashCode();
21     }
22 }

```

1.18 ./csharp/Platform.Data.Doublets/ILinks.cs

```

1  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
2
3  using System.Collections.Generic;
4
5  namespace Platform.Data.Doublets
6  {
7      public interface ILinks<TLink> : ILinks<TLink, LinksConstants<TLink>>
8      {
9      }
10 }

```

1.19 ./csharp/Platform.Data.Doublets/ILinksExtensions.cs

```

1  using System;
2  using System.Collections;
3  using System.Collections.Generic;
4  using System.Linq;
5  using System.Runtime.CompilerServices;
6  using Platform.Ranges;
7  using Platform.Collections.Arrays;
8  using Platform.Random;
9  using Platform.Setters;
10 using Platform.Converters;
11 using Platform.Numbers;
12 using Platform.Data.Exceptions;
13 using Platform.Data.Doublets.Decorators;
14
15 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
16
17 namespace Platform.Data.Doublets
18 {
19     public static class ILinksExtensions
20     {
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public static void RunRandomCreations<TLink>(this ILinks<TLink> links, ulong
23             ↳ amountOfCreations)
24         {
25             var random = RandomHelpers.Default;
26             var addressToUInt64Converter = UncheckedConverter<TLink, ulong>.Default;
27             var uint64ToAddressConverter = UncheckedConverter<ulong, TLink>.Default;
28             for (var i = 0UL; i < amountOfCreations; i++)
29             {
30                 var linksAddressRange = new Range<ulong>(0,
31                     ↳ addressToUInt64Converter.Convert(links.Count()));
32                 var source =
33                     ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
34                 var target =
35                     ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
36                 links.GetOrCreate(source, target);
37             }
38         }
39     }
40 }

```

```

35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 public static void RunRandomSearches<TLink>(this ILinks<TLink> links, ulong
37     ↳ amountOfSearches)
38 {
39     var random = RandomHelpers.Default;
40     var addressToUInt64Converter = UncheckedConverter<TLink, ulong>.Default;
41     var uint64ToAddressConverter = UncheckedConverter<ulong, TLink>.Default;
42     for (var i = 0UL; i < amountOfSearches; i++)
43     {
44         var linksAddressRange = new Range<ulong>(0,
45             ↳ addressToUInt64Converter.Convert(links.Count()));
46         var source =
47             ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
48         var target =
49             ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
50         links.SearchOrDefault(source, target);
51     }
52 }
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 public static void RunRandomDeletions<TLink>(this ILinks<TLink> links, ulong
56     ↳ amountOfDeletions)
57 {
58     var random = RandomHelpers.Default;
59     var addressToUInt64Converter = UncheckedConverter<TLink, ulong>.Default;
60     var uint64ToAddressConverter = UncheckedConverter<ulong, TLink>.Default;
61     var linksCount = addressToUInt64Converter.Convert(links.Count());
62     var min = amountOfDeletions > linksCount ? 0UL : linksCount - amountOfDeletions;
63     for (var i = 0UL; i < amountOfDeletions; i++)
64     {
65         linksCount = addressToUInt64Converter.Convert(links.Count());
66         if (linksCount <= min)
67         {
68             break;
69         }
70         var linksAddressRange = new Range<ulong>(min, linksCount);
71         var link =
72             ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
73         links.Delete(link);
74     }
75 }
76
77 [MethodImpl(MethodImplOptions.AggressiveInlining)]
78 public static void Delete<TLink>(this ILinks<TLink> links, TLink linkToDelete) =>
79     ↳ links.Delete(new LinkAddress<TLink>(linkToDelete));
80
81 /// <remarks>
82 /// TODO: Возможно есть очень простой способ это сделать.
83 /// (Например просто удалить файл, или изменить его размер таким образом,
84 /// чтобы удалился весь контент)
85 /// Например через _header->AllocatedLinks в ResizableDirectMemoryLinks
86 /// </remarks>
87 [MethodImpl(MethodImplOptions.AggressiveInlining)]
88 public static void DeleteAll<TLink>(this ILinks<TLink> links)
89 {
90     var equalityComparer = EqualityComparer<TLink>.Default;
91     var comparer = Comparer<TLink>.Default;
92     for (var i = links.Count(); comparer.Compare(i, default) > 0; i =
93         ↳ Arithmetic.Decrement(i))
94     {
95         links.Delete(i);
96         if (!equalityComparer.Equals(links.Count(), Arithmetic.Decrement(i)))
97         {
98             i = links.Count();
99         }
100     }
101 }
102
103 [MethodImpl(MethodImplOptions.AggressiveInlining)]
104 public static TLink First<TLink>(this ILinks<TLink> links)
105 {
106     TLink firstLink = default;
107     var equalityComparer = EqualityComparer<TLink>.Default;
108     if (equalityComparer.Equals(links.Count(), default))
109     {
110         throw new InvalidOperationException("В хранилище нет связей.");
111     }
112 }

```

```

105     links.Each(links.Constants.Any, links.Constants.Any, link =>
106     {
107         firstLink = link[links.Constants.IndexPart];
108         return links.Constants.Break;
109     });
110     if (equalityComparer.Equals(firstLink, default))
111     {
112         throw new InvalidOperationException("В процессе поиска по хранилищу не было
113             ↪ найдено связей.");
114     }
115     return firstLink;
116 }
117 #region Paths
118
119 /// <remarks>
120 /// TODO: Как так? Как то что ниже может быть корректно?
121 /// Скорее всего практически не применимо
122 /// Предполагалось, что можно было конвертировать формируемый в проходе через
123     ↪ SequenceWalker
124 /// Stack в конкретный путь из Source, Target до связи, но это не всегда так.
125 /// TODO: Возможно нужен метод, который именно выбрасывает исключения (EnsurePathExists)
126 /// </remarks>
127 [MethodImpl(MethodImplOptions.AggressiveInlining)]
128 public static bool CheckPathExistence<TLink>(this ILinks<TLink> links, params TLink[]
129     ↪ path)
130 {
131     var current = path[0];
132     //EnsureLinkExists(current, "path");
133     if (!links.Exists(current))
134     {
135         return false;
136     }
137     var equalityComparer = EqualityComparer<TLink>.Default;
138     var constants = links.Constants;
139     for (var i = 1; i < path.Length; i++)
140     {
141         var next = path[i];
142         var values = links.GetLink(current);
143         var source = values[constants.SourcePart];
144         var target = values[constants.TargetPart];
145         if (equalityComparer.Equals(source, target) && equalityComparer.Equals(source,
146             ↪ next))
147         {
148             //throw new InvalidOperationException(string.Format("Невозможно выбрать
149                 ↪ путь, так как и Source и Target совпадают с элементом пути {0}.", next));
150             return false;
151         }
152         if (!equalityComparer.Equals(next, source) && !equalityComparer.Equals(next,
153             ↪ target))
154         {
155             //throw new InvalidOperationException(string.Format("Невозможно продолжить
156                 ↪ путь через элемент пути {0}", next));
157             return false;
158         }
159         current = next;
160     }
161     return true;
162 }
163
164 /// <remarks>
165 /// Может потребовать дополнительного стека для PathElement's при использовании
166     ↪ SequenceWalker.
167 /// </remarks>
168 [MethodImpl(MethodImplOptions.AggressiveInlining)]
169 public static TLink GetByKeyes<TLink>(this ILinks<TLink> links, TLink root, params int[]
170     ↪ path)
171 {
172     links.EnsureLinkExists(root, "root");
173     var currentLink = root;
174     for (var i = 0; i < path.Length; i++)
175     {
176         currentLink = links.GetLink(currentLink)[path[i]];
177     }
178     return currentLink;
179 }
180
181 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

174 public static TLink GetSquareMatrixSequenceElementByIndex<TLink>(this ILinks<TLink>
    ↳ links, TLink root, ulong size, ulong index)
175 {
176     var constants = links.Constants;
177     var source = constants.SourcePart;
178     var target = constants.TargetPart;
179     if (!Platform.Numbers.Math.IsPowerOfTwo(size))
180     {
181         throw new ArgumentOutOfRangeException(nameof(size), "Sequences with sizes other
            ↳ than powers of two are not supported.");
182     }
183     var path = new BitArray(BitConverter.GetBytes(index));
184     var length = Bit.GetLowestPosition(size);
185     links.EnsureLinkExists(root, "root");
186     var currentLink = root;
187     for (var i = length - 1; i >= 0; i--)
188     {
189         currentLink = links.GetLink(currentLink)[path[i] ? target : source];
190     }
191     return currentLink;
192 }
193
194 #endregion
195
196 /// <summary>
197 /// Возвращает индекс указанной связи.
198 /// </summary>
199 /// <param name="links">Хранилище связей.</param>
200 /// <param name="link">Связь представленная списком, состоящим из её адреса и
    ↳ содержимого.</param>
201 /// <returns>Индекс начальной связи для указанной связи.</returns>
202 [MethodImpl(MethodImplOptions.AggressiveInlining)]
203 public static TLink GetIndex<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
    ↳ link[links.Constants.IndexPart];
204
205 /// <summary>
206 /// Возвращает индекс начальной (Source) связи для указанной связи.
207 /// </summary>
208 /// <param name="links">Хранилище связей.</param>
209 /// <param name="link">Индекс связи.</param>
210 /// <returns>Индекс начальной связи для указанной связи.</returns>
211 [MethodImpl(MethodImplOptions.AggressiveInlining)]
212 public static TLink GetSource<TLink>(this ILinks<TLink> links, TLink link) =>
    ↳ links.GetLink(link)[links.Constants.SourcePart];
213
214 /// <summary>
215 /// Возвращает индекс начальной (Source) связи для указанной связи.
216 /// </summary>
217 /// <param name="links">Хранилище связей.</param>
218 /// <param name="link">Связь представленная списком, состоящим из её адреса и
    ↳ содержимого.</param>
219 /// <returns>Индекс начальной связи для указанной связи.</returns>
220 [MethodImpl(MethodImplOptions.AggressiveInlining)]
221 public static TLink GetSource<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
    ↳ link[links.Constants.SourcePart];
222
223 /// <summary>
224 /// Возвращает индекс конечной (Target) связи для указанной связи.
225 /// </summary>
226 /// <param name="links">Хранилище связей.</param>
227 /// <param name="link">Индекс связи.</param>
228 /// <returns>Индекс конечной связи для указанной связи.</returns>
229 [MethodImpl(MethodImplOptions.AggressiveInlining)]
230 public static TLink GetTarget<TLink>(this ILinks<TLink> links, TLink link) =>
    ↳ links.GetLink(link)[links.Constants.TargetPart];
231
232 /// <summary>
233 /// Возвращает индекс конечной (Target) связи для указанной связи.
234 /// </summary>
235 /// <param name="links">Хранилище связей.</param>
236 /// <param name="link">Связь представленная списком, состоящим из её адреса и
    ↳ содержимого.</param>
237 /// <returns>Индекс конечной связи для указанной связи.</returns>
238 [MethodImpl(MethodImplOptions.AggressiveInlining)]
239 public static TLink GetTarget<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
    ↳ link[links.Constants.TargetPart];
240
241 /// <summary>

```



```

242 /// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
243   (handler) для каждой подходящей связи.
244 /// </summary>
245 /// <param name="links">Хранилище связей.</param>
246 /// <param name="handler">Обработчик каждой подходящей связи.</param>
247 /// <param name="restrictions">Ограничения на содержимое связей. Каждое ограничение
248   ↳ может иметь значения: Constants.Null - 0-я связь, обозначающая ссылку на пустоту,
249   ↳ Any - отсутствие ограничения, 1..∞ конкретный адрес связи.</param>
250 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
251   ↳ случае.</returns>
252 [MethodImpl(MethodImplOptions.AggressiveInlining)]
253 public static bool Each<TLink>(this ILinks<TLink> links, Func<IList<TLink>, TLink>
254   ↳ handler, params TLink[] restrictions)
255   => EqualityComparer<TLink>.Default.Equals(links.Each(handler, restrictions),
256   ↳ links.Constants.Continue);
257
258 /// <summary>
259 /// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
260   (handler) для каждой подходящей связи.
261 /// </summary>
262 /// <param name="links">Хранилище связей.</param>
263 /// <param name="source">Значение, определяющее соответствующие шаблону связи.
264   ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве начала,
265   ↳ Constants.Any - любое начало, 1..∞ конкретное начало)</param>
266 /// <param name="target">Значение, определяющее соответствующие шаблону связи.
267   ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве конца,
268   ↳ Constants.Any - любой конец, 1..∞ конкретный конец)</param>
269 /// <param name="handler">Обработчик каждой подходящей связи.</param>
270 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
271   ↳ случае.</returns>
272 [MethodImpl(MethodImplOptions.AggressiveInlining)]
273 public static bool Each<TLink>(this ILinks<TLink> links, TLink source, TLink target,
274   ↳ Func<TLink, bool> handler)
275 {
276     var constants = links.Constants;
277     return links.Each(link => handler(link[constants.IndexPart]) ? constants.Continue :
278   ↳ constants.Break, constants.Any, source, target);
279 }
280
281 /// <summary>
282 /// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
283   (handler) для каждой подходящей связи.
284 /// </summary>
285 /// <param name="links">Хранилище связей.</param>
286 /// <param name="source">Значение, определяющее соответствующие шаблону связи.
287   ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве начала,
288   ↳ Constants.Any - любое начало, 1..∞ конкретное начало)</param>
289 /// <param name="target">Значение, определяющее соответствующие шаблону связи.
290   ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве конца,
291   ↳ Constants.Any - любой конец, 1..∞ конкретный конец)</param>
292 /// <param name="handler">Обработчик каждой подходящей связи.</param>
293 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
294   ↳ случае.</returns>
295 [MethodImpl(MethodImplOptions.AggressiveInlining)]
296 public static bool Each<TLink>(this ILinks<TLink> links, TLink source, TLink target,
297   ↳ Func<IList<TLink>, TLink> handler) => links.Each(handler, links.Constants.Any,
298   ↳ source, target);
299
300 [MethodImpl(MethodImplOptions.AggressiveInlining)]
301 public static IList<IList<TLink>> All<TLink>(this ILinks<TLink> links, params TLink[]
302   ↳ restrictions)
303 {
304     var arraySize = CheckedConverter<TLink,
305   ↳ long>.Default.Convert(links.Count(restrictions));
306     if (arraySize > 0)
307     {
308         var array = new IList<TLink>[arraySize];
309         var filler = new ArrayFiller<IList<TLink>, TLink>(array,
310   ↳ links.Constants.Continue);
311         links.Each(filler.AddAndReturnConstant, restrictions);
312         return array;
313     }
314     else
315     {
316         return Array.Empty<IList<TLink>>();
317     }
318 }

```

```

293     }
294
295     [MethodImpl(MethodImplOptions.AggressiveInlining)]
296     public static IList<TLink> AllIndices<TLink>(this ILinks<TLink> links, params TLink[]
    ↳ restrictions)
297     {
298         var arraySize = CheckedConverter<TLink,
    ↳ long>.Default.Convert(links.Count(restrictions));
299         if (arraySize > 0)
300         {
301             var array = new TLink[arraySize];
302             var filler = new ArrayFiller<TLink, TLink>(array, links.Constants.Continue);
303             links.Each(filler.AddFirstAndReturnConstant, restrictions);
304             return array;
305         }
306         else
307         {
308             return Array.Empty<TLink>();
309         }
310     }
311
312     /// <summary>
313     /// Возвращает значение, определяющее существует ли связь с указанными началом и концом
    ↳ в хранилище связей.
314     /// </summary>
315     /// <param name="links">Хранилище связей.</param>
316     /// <param name="source">Начало связи.</param>
317     /// <param name="target">Конец связи.</param>
318     /// <returns>Значение, определяющее существует ли связь.</returns>
319     [MethodImpl(MethodImplOptions.AggressiveInlining)]
320     public static bool Exists<TLink>(this ILinks<TLink> links, TLink source, TLink target)
    ↳ => Comparer<TLink>.Default.Compare(links.Count(links.Constants.Any, source, target),
    ↳ default) > 0;
321
322     #region Ensure
323     // TODO: May be move to EnsureExtensions or make it both there and here
324
325     [MethodImpl(MethodImplOptions.AggressiveInlining)]
326     public static void EnsureLinkExists<TLink>(this ILinks<TLink> links, IList<TLink>
    ↳ restrictions)
327     {
328         for (var i = 0; i < restrictions.Count; i++)
329         {
330             if (!links.Exists(restrictions[i]))
331             {
332                 throw new ArgumentLinkDoesNotExistsException<TLink>(restrictions[i],
    ↳ $"sequence[{i}]");
333             }
334         }
335     }
336
337     [MethodImpl(MethodImplOptions.AggressiveInlining)]
338     public static void EnsureInnerReferenceExists<TLink>(this ILinks<TLink> links, TLink
    ↳ reference, string argumentName)
339     {
340         if (links.Constants.IsInternalReference(reference) && !links.Exists(reference))
341         {
342             throw new ArgumentLinkDoesNotExistsException<TLink>(reference, argumentName);
343         }
344     }
345
346     [MethodImpl(MethodImplOptions.AggressiveInlining)]
347     public static void EnsureInnerReferenceExists<TLink>(this ILinks<TLink> links,
    ↳ IList<TLink> restrictions, string argumentName)
348     {
349         for (int i = 0; i < restrictions.Count; i++)
350         {
351             links.EnsureInnerReferenceExists(restrictions[i], argumentName);
352         }
353     }
354
355     [MethodImpl(MethodImplOptions.AggressiveInlining)]
356     public static void EnsureLinkIsAnyOrExists<TLink>(this ILinks<TLink> links, IList<TLink>
    ↳ restrictions)
357     {
358         var equalityComparer = EqualityComparer<TLink>.Default;
359         var any = links.Constants.Any;
360         for (var i = 0; i < restrictions.Count; i++)

```

```

361     {
362         if (!equalityComparer.Equals(restrictions[i], any) &&
363             ↪ !links.Exists(restrictions[i]))
364         {
365             throw new ArgumentLinkDoesNotExistsException<TLink>(restrictions[i],
366                 ↪ $"sequence[{i}]");
367         }
368     }
369 }
370
371 [MethodImpl(MethodImplOptions.AggressiveInlining)]
372 public static void EnsureLinkIsAnyOrExists<TLink>(this ILinks<TLink> links, TLink link,
373     ↪ string argumentName)
374 {
375     var equalityComparer = EqualityComparer<TLink>.Default;
376     if (!equalityComparer.Equals(link, links.Constants.Any) && !links.Exists(link))
377     {
378         throw new ArgumentLinkDoesNotExistsException<TLink>(link, argumentName);
379     }
380 }
381
382 [MethodImpl(MethodImplOptions.AggressiveInlining)]
383 public static void EnsureLinkIsItselfOrExists<TLink>(this ILinks<TLink> links, TLink
384     ↪ link, string argumentName)
385 {
386     var equalityComparer = EqualityComparer<TLink>.Default;
387     if (!equalityComparer.Equals(link, links.Constants.Itself) && !links.Exists(link))
388     {
389         throw new ArgumentLinkDoesNotExistsException<TLink>(link, argumentName);
390     }
391 }
392
393 /// <param name="links">Хранилище связей.</param>
394 [MethodImpl(MethodImplOptions.AggressiveInlining)]
395 public static void EnsureDoesNotExists<TLink>(this ILinks<TLink> links, TLink source,
396     ↪ TLink target)
397 {
398     if (links.Exists(source, target))
399     {
400         throw new LinkWithSameValueAlreadyExistsException();
401     }
402 }
403
404 /// <param name="links">Хранилище связей.</param>
405 [MethodImpl(MethodImplOptions.AggressiveInlining)]
406 public static void EnsureNoUsages<TLink>(this ILinks<TLink> links, TLink link)
407 {
408     if (links.HasUsages(link))
409     {
410         throw new ArgumentLinkHasDependenciesException<TLink>(link);
411     }
412 }
413
414 /// <param name="links">Хранилище связей.</param>
415 [MethodImpl(MethodImplOptions.AggressiveInlining)]
416 public static void EnsureCreated<TLink>(this ILinks<TLink> links, params TLink[]
417     ↪ addresses) => links.EnsureCreated(links.Create, addresses);
418
419 /// <param name="links">Хранилище связей.</param>
420 [MethodImpl(MethodImplOptions.AggressiveInlining)]
421 public static void EnsurePointsCreated<TLink>(this ILinks<TLink> links, params TLink[]
422     ↪ addresses) => links.EnsureCreated(links.CreatePoint, addresses);
423
424 /// <param name="links">Хранилище связей.</param>
425 [MethodImpl(MethodImplOptions.AggressiveInlining)]
426 public static void EnsureCreated<TLink>(this ILinks<TLink> links, Func<TLink> creator,
427     ↪ params TLink[] addresses)
428 {
429     var addressToUInt64Converter = CheckedConverter<TLink, ulong>.Default;
430     var uInt64ToAddressConverter = CheckedConverter<ulong, TLink>.Default;
431     var nonExistentAddresses = new HashSet<TLink>(addresses.Where(x =>
432         ↪ !links.Exists(x)));
433     if (nonExistentAddresses.Count > 0)
434     {
435         var max = nonExistentAddresses.Max();

```

```

427         max = UInt64ToAddressConverter.Convert(System.Math.Min(addressToUInt64Converter.
↳ Convert(max),
↳ addressToUInt64Converter.Convert(links.Constants.InternalReferencesRange.Max
↳ imum)));
428     var createdLinks = new List<TLink>();
429     var equalityComparer = EqualityComparer<TLink>.Default;
430     TLink createdLink = creator();
431     while (!equalityComparer.Equals(createdLink, max))
432     {
433         createdLinks.Add(createdLink);
434     }
435     for (var i = 0; i < createdLinks.Count; i++)
436     {
437         if (!nonExistentAddresses.Contains(createdLinks[i]))
438         {
439             links.Delete(createdLinks[i]);
440         }
441     }
442 }
443 }
444
445 #endregion
446
447 /// <param name="links">Хранилище связей.</param>
448 [MethodImpl(MethodImplOptions.AggressiveInlining)]
449 public static TLink CountUsages<TLink>(this ILinks<TLink> links, TLink link)
450 {
451     var constants = links.Constants;
452     var values = links.GetLink(link);
453     TLink usagesAsSource = links.Count(new Link<TLink>(constants.Any, link,
↳ constants.Any));
454     var equalityComparer = EqualityComparer<TLink>.Default;
455     if (equalityComparer.Equals(values[constants.SourcePart], link))
456     {
457         usagesAsSource = Arithmetic<TLink>.Decrement(usagesAsSource);
458     }
459     TLink usagesAsTarget = links.Count(new Link<TLink>(constants.Any, constants.Any,
↳ link));
460     if (equalityComparer.Equals(values[constants.TargetPart], link))
461     {
462         usagesAsTarget = Arithmetic<TLink>.Decrement(usagesAsTarget);
463     }
464     return Arithmetic<TLink>.Add(usagesAsSource, usagesAsTarget);
465 }
466
467 /// <param name="links">Хранилище связей.</param>
468 [MethodImpl(MethodImplOptions.AggressiveInlining)]
469 public static bool HasUsages<TLink>(this ILinks<TLink> links, TLink link) =>
↳ Comparer<TLink>.Default.Compare(links.CountUsages(link), default) > 0;
470
471 /// <param name="links">Хранилище связей.</param>
472 [MethodImpl(MethodImplOptions.AggressiveInlining)]
473 public static bool Equals<TLink>(this ILinks<TLink> links, TLink link, TLink source,
↳ TLink target)
474 {
475     var constants = links.Constants;
476     var values = links.GetLink(link);
477     var equalityComparer = EqualityComparer<TLink>.Default;
478     return equalityComparer.Equals(values[constants.SourcePart], source) &&
↳ equalityComparer.Equals(values[constants.TargetPart], target);
479 }
480
481 /// <summary>
482 /// Выполняет поиск связи с указанными Source (началом) и Target (концом).
483 /// </summary>
484 /// <param name="links">Хранилище связей.</param>
485 /// <param name="source">Индекс связи, которая является началом для искомой
↳ связи.</param>
486 /// <param name="target">Индекс связи, которая является концом для искомой связи.</param>
487 /// <returns>Индекс искомой связи с указанными Source (началом) и Target
↳ (концом).</returns>
488 [MethodImpl(MethodImplOptions.AggressiveInlining)]
489 public static TLink SearchOrDefault<TLink>(this ILinks<TLink> links, TLink source, TLink
↳ target)
490 {
491     var constants = links.Constants;
492     var setter = new Setter<TLink, TLink>(constants.Continue, constants.Break, default);
493     links.Each(setter.SetFirstAndReturnFalse, constants.Any, source, target);

```

```

494     return setter.Result;
495 }
496
497 /// <param name="links">Хранилище связей.</param>
498 [MethodImpl(MethodImplOptions.AggressiveInlining)]
499 public static TLink Create<TLink>(this ILinks<TLink> links) => links.Create(null);
500
501 /// <param name="links">Хранилище связей.</param>
502 [MethodImpl(MethodImplOptions.AggressiveInlining)]
503 public static TLink CreatePoint<TLink>(this ILinks<TLink> links)
504 {
505     var link = links.Create();
506     return links.Update(link, link, link);
507 }
508
509 /// <param name="links">Хранилище связей.</param>
510 [MethodImpl(MethodImplOptions.AggressiveInlining)]
511 public static TLink CreateAndUpdate<TLink>(this ILinks<TLink> links, TLink source, TLink
    ↪ target) => links.Update(links.Create(), source, target);
512
513 /// <summary>
514 /// Обновляет связь с указанными началом (Source) и концом (Target)
515 /// на связь с указанными началом (NewSource) и концом (NewTarget).
516 /// </summary>
517 /// <param name="links">Хранилище связей.</param>
518 /// <param name="link">Индекс обновляемой связи.</param>
519 /// <param name="newSource">Индекс связи, которая является началом связи, на которую
    ↪ выполняется обновление.</param>
520 /// <param name="newTarget">Индекс связи, которая является концом связи, на которую
    ↪ выполняется обновление.</param>
521 /// <returns>Индекс обновлённой связи.</returns>
522 [MethodImpl(MethodImplOptions.AggressiveInlining)]
523 public static TLink Update<TLink>(this ILinks<TLink> links, TLink link, TLink newSource,
    ↪ TLink newTarget) => links.Update(new LinkAddress<TLink>(link), new Link<TLink>(link,
    ↪ newSource, newTarget));
524
525 /// <summary>
526 /// Обновляет связь с указанными началом (Source) и концом (Target)
527 /// на связь с указанными началом (NewSource) и концом (NewTarget).
528 /// </summary>
529 /// <param name="links">Хранилище связей.</param>
530 /// <param name="restrictions">Ограничения на содержимое связей. Каждое ограничение
    ↪ может иметь значения: Constants.Null - 0-я связь, обозначающая ссылку на пустоту,
    ↪ Itself - требование установить ссылку на себя, 1..∞ конкретный адрес другой
    ↪ связи.</param>
531 /// <returns>Индекс обновлённой связи.</returns>
532 [MethodImpl(MethodImplOptions.AggressiveInlining)]
533 public static TLink Update<TLink>(this ILinks<TLink> links, params TLink[] restrictions)
534 {
535     if (restrictions.Length == 2)
536     {
537         return links.MergeAndDelete(restrictions[0], restrictions[1]);
538     }
539     if (restrictions.Length == 4)
540     {
541         return links.UpdateOrCreateOrGet(restrictions[0], restrictions[1],
    ↪ restrictions[2], restrictions[3]);
542     }
543     else
544     {
545         return links.Update(new LinkAddress<TLink>(restrictions[0]), restrictions);
546     }
547 }
548
549 [MethodImpl(MethodImplOptions.AggressiveInlining)]
550 public static IList<TLink> ResolveConstantAsSelfReference<TLink>(this ILinks<TLink>
    ↪ links, TLink constant, IList<TLink> restrictions, IList<TLink> substitution)
551 {
552     var equalityComparer = EqualityComparer<TLink>.Default;
553     var constants = links.Constants;
554     var restrictionsIndex = restrictions[constants.IndexPart];
555     var substitutionIndex = substitution[constants.IndexPart];
556     if (equalityComparer.Equals(substitutionIndex, default))
557     {
558         substitutionIndex = restrictionsIndex;
559     }
560     var source = substitution[constants.SourcePart];
561     var target = substitution[constants.TargetPart];

```

```

562     source = equalityComparer.Equals(source, constant) ? substitutionIndex : source;
563     target = equalityComparer.Equals(target, constant) ? substitutionIndex : target;
564     return new Link<TLink>(substitutionIndex, source, target);
565 }
566
567 /// <summary>
568 /// Создаёт связь (если она не существовала), либо возвращает индекс существующей связи
569   → с указанными Source (началом) и Target (концом).
570 /// </summary>
571 /// <param name="links">Хранилище связей.</param>
572 /// <param name="source">Индекс связи, которая является началом на создаваемой
573   → связи.</param>
574 /// <param name="target">Индекс связи, которая является концом для создаваемой
575   → связи.</param>
576 /// <returns>Индекс связи, с указанным Source (началом) и Target (концом)</returns>
577 [MethodImpl(MethodImplOptions.AggressiveInlining)]
578 public static TLink GetOrCreate<TLink>(this ILinks<TLink> links, TLink source, TLink
579   → target)
580 {
581     var link = links.SearchOrDefault(source, target);
582     if (EqualityComparer<TLink>.Default.Equals(link, default))
583     {
584         link = links.CreateAndUpdate(source, target);
585     }
586     return link;
587 }
588
589 /// <summary>
590 /// Обновляет связь с указанными началом (Source) и концом (Target)
591   → на связь с указанными началом (NewSource) и концом (NewTarget).
592 /// </summary>
593 /// <param name="links">Хранилище связей.</param>
594 /// <param name="source">Индекс связи, которая является началом обновляемой
595   → связи.</param>
596 /// <param name="target">Индекс связи, которая является концом обновляемой связи.</param>
597 /// <param name="newSource">Индекс связи, которая является началом связи, на которую
598   → выполняется обновление.</param>
599 /// <param name="newTarget">Индекс связи, которая является концом связи, на которую
600   → выполняется обновление.</param>
601 /// <returns>Индекс обновлённой связи.</returns>
602 [MethodImpl(MethodImplOptions.AggressiveInlining)]
603 public static TLink UpdateOrCreateOrGet<TLink>(this ILinks<TLink> links, TLink source,
604   → TLink target, TLink newSource, TLink newTarget)
605 {
606     var equalityComparer = EqualityComparer<TLink>.Default;
607     var link = links.SearchOrDefault(source, target);
608     if (equalityComparer.Equals(link, default))
609     {
610         return links.CreateAndUpdate(newSource, newTarget);
611     }
612     if (equalityComparer.Equals(newSource, source) && equalityComparer.Equals(newTarget,
613   → target))
614     {
615         return link;
616     }
617     return links.Update(link, newSource, newTarget);
618 }
619
620 /// <summary>Удаляет связь с указанными началом (Source) и концом (Target).</summary>
621 /// <param name="links">Хранилище связей.</param>
622 /// <param name="source">Индекс связи, которая является началом удаляемой связи.</param>
623 /// <param name="target">Индекс связи, которая является концом удаляемой связи.</param>
624 [MethodImpl(MethodImplOptions.AggressiveInlining)]
625 public static TLink DeleteIfExists<TLink>(this ILinks<TLink> links, TLink source, TLink
626   → target)
627 {
628     var link = links.SearchOrDefault(source, target);
629     if (!EqualityComparer<TLink>.Default.Equals(link, default))
630     {
631         links.Delete(link);
632         return link;
633     }
634     return default;
635 }
636
637 /// <summary>Удаляет несколько связей.</summary>
638 /// <param name="links">Хранилище связей.</param>

```

```

629 /// <param name="deletedLinks">Список адресов связей к удалению.</param>
630 [MethodImpl(MethodImplOptions.AggressiveInlining)]
631 public static void DeleteMany<TLink>(this ILinks<TLink> links, IList<TLink> deletedLinks)
632 {
633     for (int i = 0; i < deletedLinks.Count; i++)
634     {
635         links.Delete(deletedLinks[i]);
636     }
637 }
638
639 /// <remarks>Before execution of this method ensure that deleted link is detached (all
640 ↪ values - source and target are reset to null) or it might enter into infinite
641 ↪ recursion.</remarks>
642 [MethodImpl(MethodImplOptions.AggressiveInlining)]
643 public static void DeleteAllUsages<TLink>(this ILinks<TLink> links, TLink linkIndex)
644 {
645     var anyConstant = links.Constants.Any;
646     var usagesAsSourceQuery = new Link<TLink>(anyConstant, linkIndex, anyConstant);
647     links.DeleteByQuery(usagesAsSourceQuery);
648     var usagesAsTargetQuery = new Link<TLink>(anyConstant, linkIndex, anyConstant);
649     links.DeleteByQuery(usagesAsTargetQuery);
650 }
651 [MethodImpl(MethodImplOptions.AggressiveInlining)]
652 public static void DeleteByQuery<TLink>(this ILinks<TLink> links, Link<TLink> query)
653 {
654     var count = CheckedConverter<TLink, long>.Default.Convert(links.Count(query));
655     if (count > 0)
656     {
657         var queryResult = new TLink[count];
658         var queryResultFiller = new ArrayFiller<TLink, TLink>(queryResult,
659             ↪ links.Constants.Continue);
660         links.Each(queryResultFiller.AddFirstAndReturnConstant, query);
661         for (var i = count - 1; i >= 0; i--)
662         {
663             links.Delete(queryResult[i]);
664         }
665     }
666 }
667
668 // TODO: Move to Platform.Data
669 [MethodImpl(MethodImplOptions.AggressiveInlining)]
670 public static bool AreValuesReset<TLink>(this ILinks<TLink> links, TLink linkIndex)
671 {
672     var nullConstant = links.Constants.Null;
673     var equalityComparer = EqualityComparer<TLink>.Default;
674     var link = links.GetLink(linkIndex);
675     for (int i = 1; i < link.Count; i++)
676     {
677         if (!equalityComparer.Equals(link[i], nullConstant))
678         {
679             return false;
680         }
681     }
682     return true;
683 }
684
685 // TODO: Create a universal version of this method in Platform.Data (with using of for
686 ↪ loop)
687 [MethodImpl(MethodImplOptions.AggressiveInlining)]
688 public static void ResetValues<TLink>(this ILinks<TLink> links, TLink linkIndex)
689 {
690     var nullConstant = links.Constants.Null;
691     var updateRequest = new Link<TLink>(linkIndex, nullConstant, nullConstant);
692     links.Update(updateRequest);
693 }
694
695 // TODO: Create a universal version of this method in Platform.Data (with using of for
696 ↪ loop)
697 [MethodImpl(MethodImplOptions.AggressiveInlining)]
698 public static void EnforceResetValues<TLink>(this ILinks<TLink> links, TLink linkIndex)
699 {
700     if (!links.AreValuesReset(linkIndex))
701     {
702         links.ResetValues(linkIndex);
703     }
704 }

```

```

702 /// <summary>
703 /// Merging two usages graphs, all children of old link moved to be children of new link
704   ↳ or deleted.
705 /// </summary>
706 [MethodImpl(MethodImplOptions.AggressiveInlining)]
707 public static TLink MergeUsages<TLink>(this ILinks<TLink> links, TLink oldLinkIndex,
708   ↳ TLink newLinkIndex)
709 {
710     var addressToInt64Converter = CheckedConverter<TLink, long>.Default;
711     var equalityComparer = EqualityComparer<TLink>.Default;
712     if (!equalityComparer.Equals(oldLinkIndex, newLinkIndex))
713     {
714         var constants = links.Constants;
715         var usagesAsSourceQuery = new Link<TLink>(constants.Any, oldLinkIndex,
716           ↳ constants.Any);
717         var usagesAsSourceCount =
718           ↳ addressToInt64Converter.Convert(links.Count(usagesAsSourceQuery));
719         var usagesAsTargetQuery = new Link<TLink>(constants.Any, constants.Any,
720           ↳ oldLinkIndex);
721         var usagesAsTargetCount =
722           ↳ addressToInt64Converter.Convert(links.Count(usagesAsTargetQuery));
723         var isStandalonePoint = Point<TLink>.IsFullPoint(links.GetLink(oldLinkIndex)) &&
724           ↳ usagesAsSourceCount == 1 && usagesAsTargetCount == 1;
725         if (!isStandalonePoint)
726         {
727             var totalUsages = usagesAsSourceCount + usagesAsTargetCount;
728             if (totalUsages > 0)
729             {
730                 var usages = ArrayPool.Allocate<TLink>(totalUsages);
731                 var usagesFiller = new ArrayFiller<TLink, TLink>(usages,
732                   ↳ links.Constants.Continue);
733                 var i = 0L;
734                 if (usagesAsSourceCount > 0)
735                 {
736                     links.Each(usagesFiller.AddFirstAndReturnConstant,
737                       ↳ usagesAsSourceQuery);
738                     for (; i < usagesAsSourceCount; i++)
739                     {
740                         var usage = usages[i];
741                         if (!equalityComparer.Equals(usage, oldLinkIndex))
742                         {
743                             links.Update(usage, newLinkIndex, links.GetTarget(usage));
744                         }
745                     }
746                 }
747                 if (usagesAsTargetCount > 0)
748                 {
749                     links.Each(usagesFiller.AddFirstAndReturnConstant,
750                       ↳ usagesAsTargetQuery);
751                     for (; i < usages.Length; i++)
752                     {
753                         var usage = usages[i];
754                         if (!equalityComparer.Equals(usage, oldLinkIndex))
755                         {
756                             links.Update(usage, links.GetSource(usage), newLinkIndex);
757                         }
758                     }
759                 }
760                 ArrayPool.Free(usages);
761             }
762         }
763     }
764     return newLinkIndex;
765 }
766
767 /// <summary>
768 /// Replace one link with another (replaced link is deleted, children are updated or
769   ↳ deleted).
770 /// </summary>
771 [MethodImpl(MethodImplOptions.AggressiveInlining)]
772 public static TLink MergeAndDelete<TLink>(this ILinks<TLink> links, TLink oldLinkIndex,
773   ↳ TLink newLinkIndex)
774 {
775     var equalityComparer = EqualityComparer<TLink>.Default;
776     if (!equalityComparer.Equals(oldLinkIndex, newLinkIndex))
777     {
778         links.MergeUsages(oldLinkIndex, newLinkIndex);
779     }
780 }

```



```

767         links.Delete(oldLinkIndex);
768     }
769     return newLinkIndex;
770 }
771
772 [MethodImpl(MethodImplOptions.AggressiveInlining)]
773 public static ILinks<TLink>
    ↳ DecorateWithAutomaticUniquenessAndUsagesResolution<TLink>(this ILinks<TLink> links)
774 {
775     links = new LinksCascadeUsagesResolver<TLink>(links);
776     links = new NonNullContentsLinkDeletionResolver<TLink>(links);
777     links = new LinksCascadeUniquenessAndUsagesResolver<TLink>(links);
778     return links;
779 }
780
781 [MethodImpl(MethodImplOptions.AggressiveInlining)]
782 public static string Format<TLink>(this ILinks<TLink> links, IList<TLink> link)
783 {
784     var constants = links.Constants;
785     return $"({link[constants.IndexPart]}: {link[constants.SourcePart]})
    ↳ {link[constants.TargetPart]}";
786 }
787
788 [MethodImpl(MethodImplOptions.AggressiveInlining)]
789 public static string Format<TLink>(this ILinks<TLink> links, TLink link) =>
    ↳ links.Format(links.GetLink(link));
790 }
791 }

```

1.20 ./csharp/Platform.Data.Doublets/ISynchronizedLinks.cs

```

1  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
2
3  namespace Platform.Data.Doublets
4  {
5      public interface ISynchronizedLinks<TLink> : ISynchronizedLinks<TLink, ILinks<TLink>,
    ↳ LinksConstants<TLink>>, ILinks<TLink>
6      {
7      }
8  }

```

1.21 ./csharp/Platform.Data.Doublets/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      public class FrequencyIncrementer<TLink> : LinksOperatorBase<TLink>, IIncrementer<TLink>
10     {
11         private static readonly EqualityComparer<TLink> _equalityComparer =
    ↳ EqualityComparer<TLink>.Default;
12
13         private readonly TLink _frequencyMarker;
14         private readonly TLink _unaryOne;
15         private readonly IIncrementer<TLink> _unaryNumberIncrementer;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public FrequencyIncrementer(ILinks<TLink> links, TLink frequencyMarker, TLink unaryOne,
    ↳ IIncrementer<TLink> unaryNumberIncrementer)
    : base(links)
19         {
20             _frequencyMarker = frequencyMarker;
21             _unaryOne = unaryOne;
22             _unaryNumberIncrementer = unaryNumberIncrementer;
23         }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public TLink Increment(TLink frequency)
27         {
28             var links = _links;
29             if (_equalityComparer.Equals(frequency, default))
30             {
31                 return links.GetOrCreate(_unaryOne, _frequencyMarker);
32             }
33             var incrementedSource =
    ↳ _unaryNumberIncrementer.Increment(links.GetSource(frequency));
34             return links.GetOrCreate(incrementedSource, _frequencyMarker);
35         }

```

```

36     }
37 }
38 }

```

1.22 ./csharp/Platform.Data.Doublets/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     public class UnaryNumberIncrementer<TLink> : LinksOperatorBase<TLink>, IIncrementer<TLink>
10    {
11        private static readonly EqualityComparer<TLink> _equalityComparer =
12            ↪ EqualityComparer<TLink>.Default;
13
14        private readonly TLink _unaryOne;
15
16        [MethodImpl(MethodImplOptions.AggressiveInlining)]
17        public UnaryNumberIncrementer(ILinks<TLink> links, TLink unaryOne) : base(links) =>
18            ↪ _unaryOne = unaryOne;
19
20        [MethodImpl(MethodImplOptions.AggressiveInlining)]
21        public TLink Increment(TLink unaryNumber)
22        {
23            var links = _links;
24            if (_equalityComparer.Equals(unaryNumber, _unaryOne))
25            {
26                return links.GetOrCreate(_unaryOne, _unaryOne);
27            }
28            var source = links.GetSource(unaryNumber);
29            var target = links.GetTarget(unaryNumber);
30            if (_equalityComparer.Equals(source, target))
31            {
32                return links.GetOrCreate(unaryNumber, _unaryOne);
33            }
34            else
35            {
36                return links.GetOrCreate(source, Increment(target));
37            }
38        }
39    }
40 }

```

1.23 ./csharp/Platform.Data.Doublets/Link.cs

```

1 using Platform.Collections.Lists;
2 using Platform.Exceptions;
3 using Platform.Ranges;
4 using Platform.Singletons;
5 using System;
6 using System.Collections;
7 using System.Collections.Generic;
8 using System.Runtime.CompilerServices;
9
10 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
11
12 namespace Platform.Data.Doublets
13 {
14     /// <summary>
15     /// Структура описывающая уникальную связь.
16     /// </summary>
17     public struct Link<TLink> : IEquatable<Link<TLink>>, IReadOnlyList<TLink>, IList<TLink>
18     {
19         public static readonly Link<TLink> Null = new Link<TLink>();
20
21         private static readonly LinksConstants<TLink> _constants =
22             ↪ Default<LinksConstants<TLink>>.Instance;
23         private static readonly EqualityComparer<TLink> _equalityComparer =
24             ↪ EqualityComparer<TLink>.Default;
25
26         private const int Length = 3;
27
28         public readonly TLink Index;
29         public readonly TLink Source;
30         public readonly TLink Target;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public Link(params TLink[] values) => SetValues(values, out Index, out Source, out
34             ↪ Target);
35     }
36 }

```

```

32
33 [MethodImpl(MethodImplOptions.AggressiveInlining)]
34 public Link(ICollection<TLink> values) => SetValues(values, out Index, out Source, out Target);
35
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 public Link(object other)
38 {
39     if (other is Link<TLink> otherLink)
40     {
41         SetValues(ref otherLink, out Index, out Source, out Target);
42     }
43     else if (other is ICollection<TLink> otherList)
44     {
45         SetValues(otherList, out Index, out Source, out Target);
46     }
47     else
48     {
49         throw new NotSupportedException();
50     }
51 }
52
53 [MethodImpl(MethodImplOptions.AggressiveInlining)]
54 public Link(ref Link<TLink> other) => SetValues(ref other, out Index, out Source, out
    ↪ Target);
55
56 [MethodImpl(MethodImplOptions.AggressiveInlining)]
57 public Link(TLink index, TLink source, TLink target)
58 {
59     Index = index;
60     Source = source;
61     Target = target;
62 }
63
64 [MethodImpl(MethodImplOptions.AggressiveInlining)]
65 private static void SetValues(ref Link<TLink> other, out TLink index, out TLink source,
    ↪ out TLink target)
66 {
67     index = other.Index;
68     source = other.Source;
69     target = other.Target;
70 }
71
72 [MethodImpl(MethodImplOptions.AggressiveInlining)]
73 private static void SetValues(ICollection<TLink> values, out TLink index, out TLink source,
    ↪ out TLink target)
74 {
75     switch (values.Count)
76     {
77         case 3:
78             index = values[0];
79             source = values[1];
80             target = values[2];
81             break;
82         case 2:
83             index = values[0];
84             source = values[1];
85             target = default;
86             break;
87         case 1:
88             index = values[0];
89             source = default;
90             target = default;
91             break;
92         default:
93             index = default;
94             source = default;
95             target = default;
96             break;
97     }
98 }
99
100 [MethodImpl(MethodImplOptions.AggressiveInlining)]
101 public override int GetHashCode() => (Index, Source, Target).GetHashCode();
102
103 [MethodImpl(MethodImplOptions.AggressiveInlining)]
104 public bool IsNull() => _equalityComparer.Equals(Index, _constants.Null)
105     && _equalityComparer.Equals(Source, _constants.Null)
106     && _equalityComparer.Equals(Target, _constants.Null);
107
108 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

109 public override bool Equals(object other) => other is Link<TLink> &&
    ↳ Equals((Link<TLink>)other);
110
111 [MethodImpl(MethodImplOptions.AggressiveInlining)]
112 public bool Equals(Link<TLink> other) => _equalityComparer.Equals(Index, other.Index)
113                                     && _equalityComparer.Equals(Source, other.Source)
114                                     && _equalityComparer.Equals(Target, other.Target);
115
116 [MethodImpl(MethodImplOptions.AggressiveInlining)]
117 public static string ToString(TLink index, TLink source, TLink target) => $"({index}:
    ↳ {source}->{target})";
118
119 [MethodImpl(MethodImplOptions.AggressiveInlining)]
120 public static string ToString(TLink source, TLink target) => $"({source}->{target})";
121
122 [MethodImpl(MethodImplOptions.AggressiveInlining)]
123 public static implicit operator TLink[](Link<TLink> link) => link.ToArray();
124
125 [MethodImpl(MethodImplOptions.AggressiveInlining)]
126 public static implicit operator Link<TLink>(TLink[] linkArray) => new
    ↳ Link<TLink>(linkArray);
127
128 [MethodImpl(MethodImplOptions.AggressiveInlining)]
129 public override string ToString() => _equalityComparer.Equals(Index, _constants.Null) ?
    ↳ ToString(Source, Target) : ToString(Index, Source, Target);
130
131 #region IList
132
133 public int Count
134 {
135     [MethodImpl(MethodImplOptions.AggressiveInlining)]
136     get => Length;
137 }
138
139 public bool IsReadOnly
140 {
141     [MethodImpl(MethodImplOptions.AggressiveInlining)]
142     get => true;
143 }
144
145 public TLink this[int index]
146 {
147     [MethodImpl(MethodImplOptions.AggressiveInlining)]
148     get
149     {
150         Ensure.OnDebug.ArgumentInRange(index, new Range<int>(0, Length - 1),
            ↳ nameof(index));
151         if (index == _constants.IndexPart)
152         {
153             return Index;
154         }
155         if (index == _constants.SourcePart)
156         {
157             return Source;
158         }
159         if (index == _constants.TargetPart)
160         {
161             return Target;
162         }
163         throw new NotSupportedException(); // Impossible path due to
            ↳ Ensure.ArgumentInRange
164     }
165     [MethodImpl(MethodImplOptions.AggressiveInlining)]
166     set => throw new NotSupportedException();
167 }
168
169 [MethodImpl(MethodImplOptions.AggressiveInlining)]
170 IEnumerator IEnumerable.GetEnumerator() => GetEnumerator();
171
172 [MethodImpl(MethodImplOptions.AggressiveInlining)]
173 public IEnumerator<TLink> GetEnumerator()
174 {
175     yield return Index;
176     yield return Source;
177     yield return Target;
178 }
179
180 [MethodImpl(MethodImplOptions.AggressiveInlining)]
181 public void Add(TLink item) => throw new NotSupportedException();

```

```

182 [MethodImpl(MethodImplOptions.AggressiveInlining)]
183 public void Clear() => throw new NotSupportedException();
184
185 [MethodImpl(MethodImplOptions.AggressiveInlining)]
186 public bool Contains(TLink item) => IndexOf(item) >= 0;
187
188 [MethodImpl(MethodImplOptions.AggressiveInlining)]
189 public void CopyTo(TLink[] array, int arrayIndex)
190 {
191     Ensure.OnDebug.ArgumentNotNull(array, nameof(array));
192     Ensure.OnDebug.ArgumentInRange(arrayIndex, new Range<int>(0, array.Length - 1),
193         ↪ nameof(arrayIndex));
194     if (arrayIndex + Length > array.Length)
195     {
196         throw new InvalidOperationException();
197     }
198     array[arrayIndex++] = Index;
199     array[arrayIndex++] = Source;
200     array[arrayIndex] = Target;
201 }
202
203 [MethodImpl(MethodImplOptions.AggressiveInlining)]
204 public bool Remove(TLink item) => Throw.A.NotSupportedExceptionAndReturn<bool>();
205
206 [MethodImpl(MethodImplOptions.AggressiveInlining)]
207 public int IndexOf(TLink item)
208 {
209     if (_equalityComparer.Equals(Index, item))
210     {
211         return _constants.IndexPart;
212     }
213     if (_equalityComparer.Equals(Source, item))
214     {
215         return _constants.SourcePart;
216     }
217     if (_equalityComparer.Equals(Target, item))
218     {
219         return _constants.TargetPart;
220     }
221     return -1;
222 }
223
224 [MethodImpl(MethodImplOptions.AggressiveInlining)]
225 public void Insert(int index, TLink item) => throw new NotSupportedException();
226
227 [MethodImpl(MethodImplOptions.AggressiveInlining)]
228 public void RemoveAt(int index) => throw new NotSupportedException();
229
230 [MethodImpl(MethodImplOptions.AggressiveInlining)]
231 public static bool operator ==(Link<TLink> left, Link<TLink> right) =>
232     ↪ left.Equals(right);
233
234 [MethodImpl(MethodImplOptions.AggressiveInlining)]
235 public static bool operator !=(Link<TLink> left, Link<TLink> right) => !(left == right);
236
237 #endregion
238 }

```

1.24 ./csharp/Platform.Data.Doublets/LinkExtensions.cs

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets
6 {
7     public static class LinkExtensions
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public static bool IsFullPoint<TLink>(this Link<TLink> link) =>
11            ↪ Point<TLink>.IsFullPoint(link);
12
13        [MethodImpl(MethodImplOptions.AggressiveInlining)]
14        public static bool IsPartialPoint<TLink>(this Link<TLink> link) =>
15            ↪ Point<TLink>.IsPartialPoint(link);
16    }
17 }

```

1.25 ./csharp/Platform.Data.Doublets/LinksOperatorBase.cs

```
1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets
6 {
7     public abstract class LinksOperatorBase<TLink>
8     {
9         protected readonly ILinks<TLink> _links;
10
11         public ILinks<TLink> Links
12         {
13             [MethodImpl(MethodImplOptions.AggressiveInlining)]
14             get => _links;
15         }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected LinksOperatorBase(ILinks<TLink> links) => _links = links;
19     }
20 }
```

1.26 ./csharp/Platform.Data.Doublets/Memory/ILinksListMethods.cs

```
1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Memory
6 {
7     public interface ILinksListMethods<TLink>
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10         void Detach(TLink freeLink);
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         void AttachAsFirst(TLink link);
14     }
15 }
```

1.27 ./csharp/Platform.Data.Doublets/Memory/ILinksTreeMethods.cs

```
1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Memory
8 {
9     public interface ILinksTreeMethods<TLink>
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         TLink CountUsages(TLink root);
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         TLink Search(TLink source, TLink target);
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         TLink EachUsage(TLink root, Func<IList<TLink>, TLink> handler);
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         void Detach(ref TLink root, TLink linkIndex);
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         void Attach(ref TLink root, TLink linkIndex);
25     }
26 }
```

1.28 ./csharp/Platform.Data.Doublets/Memory/IndexTreeType.cs

```
1 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
2
3 namespace Platform.Data.Doublets.Memory
4 {
5     public enum IndexTreeType
6     {
7         Default = 0,
8         SizeBalancedTree = 1,
9         RecursionlessSizeBalancedTree = 2,
10        SizedAndThreadedAVLBalancedTree = 3
11    }
12 }
```

1.29 ./csharp/Platform.Data.Doublets/Memory/LinksHeader.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Unsafe;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Memory
9  {
10     public struct LinksHeader<TLink> : IEquatable<LinksHeader<TLink>>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
13             ↳ EqualityComparer<TLink>.Default;
14
15         public static readonly long SizeInBytes = Structure<LinksHeader<TLink>>.Size;
16
17         public TLink AllocatedLinks;
18         public TLink ReservedLinks;
19         public TLink FreeLinks;
20         public TLink FirstFreeLink;
21         public TLink RootAsSource;
22         public TLink RootAsTarget;
23         public TLink LastFreeLink;
24         public TLink Reserved8;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public override bool Equals(object obj) => obj is LinksHeader<TLink> linksHeader ?
28             ↳ Equals(linksHeader) : false;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public bool Equals(LinksHeader<TLink> other)
32             => _equalityComparer.Equals(AllocatedLinks, other.AllocatedLinks)
33             && _equalityComparer.Equals(ReservedLinks, other.ReservedLinks)
34             && _equalityComparer.Equals(FreeLinks, other.FreeLinks)
35             && _equalityComparer.Equals(FirstFreeLink, other.FirstFreeLink)
36             && _equalityComparer.Equals(RootAsSource, other.RootAsSource)
37             && _equalityComparer.Equals(RootAsTarget, other.RootAsTarget)
38             && _equalityComparer.Equals(LastFreeLink, other.LastFreeLink)
39             && _equalityComparer.Equals(Reserved8, other.Reserved8);
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         public override int GetHashCode() => (AllocatedLinks, ReservedLinks, FreeLinks,
43             ↳ FirstFreeLink, RootAsSource, RootAsTarget, LastFreeLink, Reserved8).GetHashCode();
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public static bool operator ==(LinksHeader<TLink> left, LinksHeader<TLink> right) =>
47             ↳ left.Equals(right);
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         public static bool operator !=(LinksHeader<TLink> left, LinksHeader<TLink> right) =>
51             ↳ !(left == right);
52     }
53 }

```

1.30 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksSizeBalancedTreeMethodsBase.cs

```

1  using System;
2  using System.Text;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Collections.Methods.Trees;
6  using Platform.Converters;
7  using static System.Runtime.CompilerServices.Unsafe;
8
9  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
10
11 namespace Platform.Data.Doublets.Memory.Split.Generic
12 {
13     public unsafe abstract class ExternalLinksSizeBalancedTreeMethodsBase<TLink> :
14         ↳ SizeBalancedTreeMethods<TLink>, ILinksTreeMethods<TLink>
15     {
16         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
17             ↳ UncheckedConverter<TLink, long>.Default;
18
19         protected readonly TLink Break;
20         protected readonly TLink Continue;
21         protected readonly byte* LinksDataParts;
22         protected readonly byte* LinksIndexParts;
23         protected readonly byte* Header;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

24     protected ExternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants,
25         ↳ byte* linksDataParts, byte* linksIndexParts, byte* header)
26     {
27         LinksDataParts = linksDataParts;
28         LinksIndexParts = linksIndexParts;
29         Header = header;
30         Break = constants.Break;
31         Continue = constants.Continue;
32     }
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected abstract TLink GetTreeRoot();
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected abstract TLink GetBasePartValue(TLink link);
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
42         ↳ rootSource, TLink rootTarget);
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
46         ↳ rootSource, TLink rootTarget);
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
50         ↳ AsRef<LinksHeader<TLink>>(Header);
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
54         ↳ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
55         ↳ _addressToInt64Converter.Convert(link)));
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
59         ↳ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
60         ↳ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
64     {
65         ref var link = ref GetLinkDataPartReference(linkIndex);
66         return new Link<TLink>(linkIndex, link.Source, link.Target);
67     }
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
71     {
72         ref var firstLink = ref GetLinkDataPartReference(first);
73         ref var secondLink = ref GetLinkDataPartReference(second);
74         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
75             ↳ secondLink.Source, secondLink.Target);
76     }
77
78     [MethodImpl(MethodImplOptions.AggressiveInlining)]
79     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
80     {
81         ref var firstLink = ref GetLinkDataPartReference(first);
82         ref var secondLink = ref GetLinkDataPartReference(second);
83         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
84             ↳ secondLink.Source, secondLink.Target);
85     }
86
87     public TLink this[TLink index]
88     {
89         [MethodImpl(MethodImplOptions.AggressiveInlining)]
90         get
91         {
92             var root = GetTreeRoot();
93             if (GreaterOrEqualThan(index, GetSize(root)))
94             {
95                 return Zero;
96             }
97             while (!EqualToZero(root))
98             {
99                 var left = GetLeftOrDefault(root);
100                 var leftSize = GetSizeOrZero(left);
101                 if (LessThan(index, leftSize))

```



```

92         {
93             root = left;
94             continue;
95         }
96         if (AreEqual(index, leftSize))
97         {
98             return root;
99         }
100         root = GetRightOrDefault(root);
101         index = Subtract(index, Increment(leftSize));
102     }
103     return Zero; // TODO: Impossible situation exception (only if tree structure
104                   ↳ broken)
105 }
106
107 /// <summary>
108 /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
109   ↳ (концом).
110 /// </summary>
111 /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
112 /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
113 /// <returns>Индекс искомой связи.</returns>
114 [MethodImpl(MethodImplOptions.AggressiveInlining)]
115 public TLink Search(TLink source, TLink target)
116 {
117     var root = GetTreeRoot();
118     while (!EqualToZero(root))
119     {
120         ref var rootLink = ref GetLinkDataPartReference(root);
121         var rootSource = rootLink.Source;
122         var rootTarget = rootLink.Target;
123         if (FirstIsToTheLeftOfSecond(source, target, rootSource, rootTarget)) //
124             ↳ node.Key < root.Key
125         {
126             root = GetLeftOrDefault(root);
127         }
128         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
129             ↳ node.Key > root.Key
130         {
131             root = GetRightOrDefault(root);
132         }
133         else // node.Key == root.Key
134         {
135             return root;
136         }
137     }
138     return Zero;
139 }
140
141 // TODO: Return indices range instead of references count
142 [MethodImpl(MethodImplOptions.AggressiveInlining)]
143 public TLink CountUsages(TLink link)
144 {
145     var root = GetTreeRoot();
146     var total = GetSize(root);
147     var totalRightIgnore = Zero;
148     while (!EqualToZero(root))
149     {
150         var @base = GetBasePartValue(root);
151         if (LessOrEqualThan(@base, link))
152         {
153             root = GetRightOrDefault(root);
154         }
155         else
156         {
157             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
158             root = GetLeftOrDefault(root);
159         }
160     }
161     root = GetTreeRoot();
162     var totalLeftIgnore = Zero;
163     while (!EqualToZero(root))
164     {
165         var @base = GetBasePartValue(root);
166         if (GreaterOrEqualThan(@base, link))
167         {
168             root = GetLeftOrDefault(root);
169         }
170     }
171     return total - totalLeftIgnore - totalRightIgnore;
172 }

```

```

166     }
167     else
168     {
169         totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
170         root = GetRightOrDefault(root);
171     }
172 }
173 return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
174 }
175
176 [MethodImpl(MethodImplOptions.AggressiveInlining)]
177 public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
178     ↳ EachUsageCore(@base, GetTreeRoot(), handler);
179
180 // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
181 ↳ low-level MSIL stack.
182 [MethodImpl(MethodImplOptions.AggressiveInlining)]
183 private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
184 {
185     var @continue = Continue;
186     if (EqualToZero(link))
187     {
188         return @continue;
189     }
190     var linkBasePart = GetBasePartValue(link);
191     var @break = Break;
192     if (GreaterThan(linkBasePart, @base))
193     {
194         if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
195         {
196             return @break;
197         }
198     }
199     else if (LessThan(linkBasePart, @base))
200     {
201         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
202         {
203             return @break;
204         }
205     }
206     else //if (linkBasePart == @base)
207     {
208         if (AreEqual(handler(GetLinkValues(link)), @break))
209         {
210             return @break;
211         }
212         if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
213         {
214             return @break;
215         }
216         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
217         {
218             return @break;
219         }
220     }
221     return @continue;
222 }
223
224 [MethodImpl(MethodImplOptions.AggressiveInlining)]
225 protected override void PrintNodeValue(TLink node, StringBuilder sb)
226 {
227     ref var link = ref GetLinkDataPartReference(node);
228     sb.Append(' ');
229     sb.Append(link.Source);
230     sb.Append('-');
231     sb.Append('>');
232     sb.Append(link.Target);
233 }

```

1.31 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksSourcesSizeBalancedTreeMethods.cs

```

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

```

```

7 public unsafe class ExternalLinksSourcesSizeBalancedTreeMethods<TLink> :
  ↳ ExternalLinksSizeBalancedTreeMethodsBase<TLink>
8 {
9     [MethodImpl(MethodImplOptions.AggressiveInlining)]
10    public ExternalLinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink> constants,
  ↳ byte* linksDataParts, byte* linksIndexParts, byte* header) : base(constants,
  ↳ linksDataParts, linksIndexParts, header) { }
11
12    [MethodImpl(MethodImplOptions.AggressiveInlining)]
13    protected override ref TLink GetLeftReference(TLink node) => ref
  ↳ GetLinkIndexPartReference(node).LeftAsSource;
14
15    [MethodImpl(MethodImplOptions.AggressiveInlining)]
16    protected override ref TLink GetRightReference(TLink node) => ref
  ↳ GetLinkIndexPartReference(node).RightAsSource;
17
18    [MethodImpl(MethodImplOptions.AggressiveInlining)]
19    protected override TLink GetLeft(TLink node) =>
  ↳ GetLinkIndexPartReference(node).LeftAsSource;
20
21    [MethodImpl(MethodImplOptions.AggressiveInlining)]
22    protected override TLink GetRight(TLink node) =>
  ↳ GetLinkIndexPartReference(node).RightAsSource;
23
24    [MethodImpl(MethodImplOptions.AggressiveInlining)]
25    protected override void SetLeft(TLink node, TLink left) =>
  ↳ GetLinkIndexPartReference(node).LeftAsSource = left;
26
27    [MethodImpl(MethodImplOptions.AggressiveInlining)]
28    protected override void SetRight(TLink node, TLink right) =>
  ↳ GetLinkIndexPartReference(node).RightAsSource = right;
29
30    [MethodImpl(MethodImplOptions.AggressiveInlining)]
31    protected override TLink GetSize(TLink node) =>
  ↳ GetLinkIndexPartReference(node).SizeAsSource;
32
33    [MethodImpl(MethodImplOptions.AggressiveInlining)]
34    protected override void SetSize(TLink node, TLink size) =>
  ↳ GetLinkIndexPartReference(node).SizeAsSource = size;
35
36    [MethodImpl(MethodImplOptions.AggressiveInlining)]
37    protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
38
39    [MethodImpl(MethodImplOptions.AggressiveInlining)]
40    protected override TLink GetBasePartValue(TLink link) =>
  ↳ GetLinkDataPartReference(link).Source;
41
42    [MethodImpl(MethodImplOptions.AggressiveInlining)]
43    protected override bool FirstIsToLeftOfSecond(TLink firstSource, TLink firstTarget,
  ↳ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
  ↳ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
44
45    [MethodImpl(MethodImplOptions.AggressiveInlining)]
46    protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
  ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
  ↳ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
47
48    [MethodImpl(MethodImplOptions.AggressiveInlining)]
49    protected override void ClearNode(TLink node)
50    {
51        ref var link = ref GetLinkIndexPartReference(node);
52        link.LeftAsSource = Zero;
53        link.RightAsSource = Zero;
54        link.SizeAsSource = Zero;
55    }
56 }
57 }

```

1.32 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksTargetsSizeBalancedTreeMethods.cs

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Memory.Split.Generic
6 {
7     public unsafe class ExternalLinksTargetsSizeBalancedTreeMethods<TLink> :
  ↳ ExternalLinksSizeBalancedTreeMethodsBase<TLink>
8     {

```

```

9      [MethodImpl(MethodImplOptions.AggressiveInlining)]
10     public ExternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink> constants,
    ↪     byte* linksDataParts, byte* linksIndexParts, byte* header) : base(constants,
    ↪     linksDataParts, linksIndexParts, header) { }

11
12     [MethodImpl(MethodImplOptions.AggressiveInlining)]
13     protected override ref TLink GetLeftReference(TLink node) => ref
    ↪     GetLinkIndexPartReference(node).LeftAsTarget;

14
15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     protected override ref TLink GetRightReference(TLink node) => ref
    ↪     GetLinkIndexPartReference(node).RightAsTarget;

17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     protected override TLink GetLeft(TLink node) =>
    ↪     GetLinkIndexPartReference(node).LeftAsTarget;

20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override TLink GetRight(TLink node) =>
    ↪     GetLinkIndexPartReference(node).RightAsTarget;

23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override void SetLeft(TLink node, TLink left) =>
    ↪     GetLinkIndexPartReference(node).LeftAsTarget = left;

26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override void SetRight(TLink node, TLink right) =>
    ↪     GetLinkIndexPartReference(node).RightAsTarget = right;

29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     protected override TLink GetSize(TLink node) =>
    ↪     GetLinkIndexPartReference(node).SizeAsTarget;

32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override void SetSize(TLink node, TLink size) =>
    ↪     GetLinkIndexPartReference(node).SizeAsTarget = size;

35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override TLink GetTreeRoot() => GetHeaderReference().RootAsTarget;

38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override TLink GetBasePartValue(TLink link) =>
    ↪     GetLinkDataPartReference(link).Target;

41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
    ↪     TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
    ↪     (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));

44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
    ↪     TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
    ↪     (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));

47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override void ClearNode(TLink node)
50     {
51         ref var link = ref GetLinkIndexPartReference(node);
52         link.LeftAsTarget = Zero;
53         link.RightAsTarget = Zero;
54         link.SizeAsTarget = Zero;
55     }
56 }
57 }

```

1.33 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksSizeBalancedTreeMethodsBase.cs

```

1  using System;
2  using System.Text;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Collections.Methods.Trees;
6  using Platform.Converters;
7  using static System.Runtime.CompilerServices.Unsafe;
8
9  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
10
11 namespace Platform.Data.Doublets.Memory.Split.Generic
12 {

```

```

13 public unsafe abstract class InternalLinksSizeBalancedTreeMethodsBase<TLink> :
    ↳ SizeBalancedTreeMethods<TLink>, ILinksTreeMethods<TLink>
14 {
15     private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
        ↳ UncheckedConverter<TLink, long>.Default;
16
17     protected readonly TLink Break;
18     protected readonly TLink Continue;
19     protected readonly byte* LinksDataParts;
20     protected readonly byte* LinksIndexParts;
21     protected readonly byte* Header;
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected InternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants,
        ↳ byte* linksDataParts, byte* linksIndexParts, byte* header)
25     {
26         LinksDataParts = linksDataParts;
27         LinksIndexParts = linksIndexParts;
28         Header = header;
29         Break = constants.Break;
30         Continue = constants.Continue;
31     }
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected abstract TLink GetTreeRoot(TLink link);
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected abstract TLink GetBasePartValue(TLink link);
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected abstract TLink GetKeyPartValue(TLink link);
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
        ↳ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
        ↳ _addressToInt64Converter.Convert(link)));
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
        ↳ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
        ↳ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second) =>
        ↳ LessThan(GetKeyPartValue(first), GetKeyPartValue(second));
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
        ↳ GreaterThan(GetKeyPartValue(first), GetKeyPartValue(second));
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
56     {
57         ref var link = ref GetLinkDataPartReference(linkIndex);
58         return new Link<TLink>(linkIndex, link.Source, link.Target);
59     }
60
61     public TLink this[TLink link, TLink index]
62     {
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         get
65         {
66             var root = GetTreeRoot(link);
67             if (GreaterOrEqualThan(index, GetSize(root)))
68             {
69                 return Zero;
70             }
71             while (!EqualToZero(root))
72             {
73                 var left = GetLeftOrDefault(root);
74                 var leftSize = GetSizeOrZero(left);
75                 if (LessThan(index, leftSize))
76                 {
77                     root = left;
78                     continue;
79                 }
80                 if (AreEqual(index, leftSize))
81                 {
82                     return root;

```

```

83         }
84         root = GetRightOrDefault(root);
85         index = Subtract(index, Increment(leftSize));
86     }
87     return Zero; // TODO: Impossible situation exception (only if tree structure
    ↪ broken)
88 }
89 }
90
91 /// <summary>
92 /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
    ↪ (концом).
93 /// </summary>
94 /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
95 /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
96 /// <returns>Индекс искомой связи.</returns>
97 [MethodImpl(MethodImplOptions.AggressiveInlining)]
98 public abstract TLink Search(TLink source, TLink target);
99
100 [MethodImpl(MethodImplOptions.AggressiveInlining)]
101 protected TLink SearchCore(TLink root, TLink key)
102 {
103     while (!EqualToZero(root))
104     {
105         var rootKey = GetKeyPartValue(root);
106         if (LessThan(key, rootKey)) // node.Key < root.Key
107         {
108             root = GetLeftOrDefault(root);
109         }
110         else if (GreaterThan(key, rootKey)) // node.Key > root.Key
111         {
112             root = GetRightOrDefault(root);
113         }
114         else // node.Key == root.Key
115         {
116             return root;
117         }
118     }
119     return Zero;
120 }
121
122 // TODO: Return indices range instead of references count
123 [MethodImpl(MethodImplOptions.AggressiveInlining)]
124 public TLink CountUsages(TLink link) => GetSizeOrZero(GetTreeRoot(link));
125
126 [MethodImpl(MethodImplOptions.AggressiveInlining)]
127 public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
    ↪ EachUsageCore(@base, GetTreeRoot(@base), handler);
128
129 // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
    ↪ low-level MSIL stack.
130 [MethodImpl(MethodImplOptions.AggressiveInlining)]
131 private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
132 {
133     var @continue = Continue;
134     if (EqualToZero(link))
135     {
136         return @continue;
137     }
138     var @break = Break;
139     if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
140     {
141         return @break;
142     }
143     if (AreEqual(handler(GetLinkValues(link)), @break))
144     {
145         return @break;
146     }
147     if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
148     {
149         return @break;
150     }
151     return @continue;
152 }
153
154 [MethodImpl(MethodImplOptions.AggressiveInlining)]
155 protected override void PrintNodeValue(TLink node, StringBuilder sb)
156 {
157     ref var link = ref GetLinkDataPartReference(node);

```

```

158         sb.Append(' ');
159         sb.Append(link.Source);
160         sb.Append('-');
161         sb.Append('>');
162         sb.Append(link.Target);
163     }
164 }
165 }

```

1.34 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksSourcesSizeBalancedTreeMethods.cs

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Data.Doublets.Memory.Split.Generic
6  {
7      public unsafe class InternalLinksSourcesSizeBalancedTreeMethods<TLink> :
8          ↳ InternalLinksSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public InternalLinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink> constants,
12             ↳ byte* linksDataParts, byte* linksIndexParts, byte* header) : base(constants,
13             ↳ linksDataParts, linksIndexParts, header) { }
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         protected override ref TLink GetLeftReference(TLink node) => ref
17             ↳ GetLinkIndexPartReference(node).LeftAsSource;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         protected override ref TLink GetRightReference(TLink node) => ref
21             ↳ GetLinkIndexPartReference(node).RightAsSource;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override TLink GetLeft(TLink node) =>
25             ↳ GetLinkIndexPartReference(node).LeftAsSource;
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         protected override TLink GetRight(TLink node) =>
29             ↳ GetLinkIndexPartReference(node).RightAsSource;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33             ↳ GetLinkIndexPartReference(node).LeftAsSource = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37             ↳ GetLinkIndexPartReference(node).RightAsSource = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) =>
41             ↳ GetLinkIndexPartReference(node).SizeAsSource;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override void SetSize(TLink node, TLink size) =>
45             ↳ GetLinkIndexPartReference(node).SizeAsSource = size;
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override TLink GetTreeRoot(TLink link) =>
49             ↳ GetLinkIndexPartReference(link).RootAsSource;
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override TLink GetBasePartValue(TLink link) =>
53             ↳ GetLinkDataPartReference(link).Source;
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override TLink GetKeyPartValue(TLink link) =>
57             ↳ GetLinkDataPartReference(link).Target;
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(TLink node)
61         {
62             ref var link = ref GetLinkIndexPartReference(node);
63             link.LeftAsSource = Zero;
64             link.RightAsSource = Zero;
65             link.SizeAsSource = Zero;
66         }
67
68         public override TLink Search(TLink source, TLink target) =>
69             ↳ SearchCore(GetTreeRoot(source), target);

```

```

55     }
56 }

```

1.35 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksTargetsSizeBalancedTreeMethods.cs

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Data.Doublets.Memory.Split.Generic
6  {
7      public unsafe class InternalLinksTargetsSizeBalancedTreeMethods<TLink> :
8          ↳ InternalLinksSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public InternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink> constants,
12             ↳ byte* linksDataParts, byte* linksIndexParts, byte* header) : base(constants,
13             ↳ linksDataParts, linksIndexParts, header) { }
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         protected override ref TLink GetLeftReference(TLink node) => ref
17             ↳ GetLinkIndexPartReference(node).LeftAsTarget;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         protected override ref TLink GetRightReference(TLink node) => ref
21             ↳ GetLinkIndexPartReference(node).RightAsTarget;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override TLink GetLeft(TLink node) =>
25             ↳ GetLinkIndexPartReference(node).LeftAsTarget;
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         protected override TLink GetRight(TLink node) =>
29             ↳ GetLinkIndexPartReference(node).RightAsTarget;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33             ↳ GetLinkIndexPartReference(node).LeftAsTarget = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37             ↳ GetLinkIndexPartReference(node).RightAsTarget = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) =>
41             ↳ GetLinkIndexPartReference(node).SizeAsTarget;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override void SetSize(TLink node, TLink size) =>
45             ↳ GetLinkIndexPartReference(node).SizeAsTarget = size;
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override TLink GetTreeRoot(TLink link) =>
49             ↳ GetLinkIndexPartReference(link).RootAsTarget;
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override TLink GetBasePartValue(TLink link) =>
53             ↳ GetLinkDataPartReference(link).Target;
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override TLink GetKeyPartValue(TLink link) =>
57             ↳ GetLinkDataPartReference(link).Source;
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(TLink node)
61         {
62             ref var link = ref GetLinkIndexPartReference(node);
63             link.LeftAsTarget = Zero;
64             link.RightAsTarget = Zero;
65             link.SizeAsTarget = Zero;
66         }
67
68         public override TLink Search(TLink source, TLink target) =>
69             ↳ SearchCore(GetTreeRoot(target), source);
70     }
71 }

```

1.36 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/SplitMemoryLinks.cs

```

1  using System;
2  using System.Runtime.CompilerServices;

```



```

3 using Platform.Singletons;
4 using Platform.Memory;
5 using static System.Runtime.CompilerServices.Unsafe;
6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublets.Memory.Split.Generic
10 {
11     public unsafe class SplitMemoryLinks<TLink> : SplitMemoryLinksBase<TLink>
12     {
13         private readonly Func<ILinksTreeMethods<TLink>> _createInternalSourceTreeMethods;
14         private readonly Func<ILinksTreeMethods<TLink>> _createExternalSourceTreeMethods;
15         private readonly Func<ILinksTreeMethods<TLink>> _createInternalTargetTreeMethods;
16         private readonly Func<ILinksTreeMethods<TLink>> _createExternalTargetTreeMethods;
17         private byte* _header;
18         private byte* _linksDataParts;
19         private byte* _linksIndexParts;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
23             ↪ indexMemory) : this(dataMemory, indexMemory, DefaultLinksSizeStep) { }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
27             ↪ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
28             ↪ memoryReservationStep, Default<LinksConstants<TLink>>.Instance) { }
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
32             ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants) :
33             ↪ base(dataMemory, indexMemory, memoryReservationStep, constants)
34         {
35             _createInternalSourceTreeMethods = () => new
36                 ↪ InternalLinksSourcesSizeBalancedTreeMethods<TLink>(Constants, _linksDataParts,
37                 ↪ _linksIndexParts, _header);
38             _createExternalSourceTreeMethods = () => new
39                 ↪ ExternalLinksSourcesSizeBalancedTreeMethods<TLink>(Constants, _linksDataParts,
40                 ↪ _linksIndexParts, _header);
41             _createInternalTargetTreeMethods = () => new
42                 ↪ InternalLinksTargetsSizeBalancedTreeMethods<TLink>(Constants, _linksDataParts,
43                 ↪ _linksIndexParts, _header);
44             _createExternalTargetTreeMethods = () => new
45                 ↪ ExternalLinksTargetsSizeBalancedTreeMethods<TLink>(Constants, _linksDataParts,
46                 ↪ _linksIndexParts, _header);
47             Init(dataMemory, indexMemory);
48         }
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override void SetPointers(IResizableDirectMemory dataMemory,
52             ↪ IResizableDirectMemory indexMemory)
53         {
54             _linksDataParts = (byte*)dataMemory.Pointer;
55             _linksIndexParts = (byte*)indexMemory.Pointer;
56             _header = _linksIndexParts;
57             InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
58             ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
59             InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
60             ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
61             UnusedLinksListMethods = new UnusedLinksListMethods<TLink>(_linksDataParts, _header);
62         }
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         protected override void ResetPointers()
66         {
67             base.ResetPointers();
68             _linksDataParts = null;
69             _linksIndexParts = null;
70             _header = null;
71         }
72
73         [MethodImpl(MethodImplOptions.AggressiveInlining)]
74         protected override ref LinksHeader<TLink> GetHeaderReference() => ref
75             ↪ AsRef<LinksHeader<TLink>>(_header);
76
77         [MethodImpl(MethodImplOptions.AggressiveInlining)]
78         protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
79             ↪ => ref AsRef<RawLinkDataPart<TLink>>(_linksDataParts + (LinkDataPartSizeInBytes *
80             ↪ ConvertToInt64(linkIndex)));
81     }
82 }

```

```

65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
    ↪ linkIndex) => ref AsRef<RawLinkIndexPart<TLink>>(_linksIndexParts +
    ↪ (LinkIndexPartSizeInBytes * ConvertToInt64(linkIndex)));
67 }
68 }

```

1.37 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/SplitMemoryLinksBase.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Disposables;
5  using Platform.Singletons;
6  using Platform.Converters;
7  using Platform.Numbers;
8  using Platform.Memory;
9  using Platform.Data.Exceptions;
10
11 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
12
13 namespace Platform.Data.Doublets.Memory.Split.Generic
14 {
15     public abstract class SplitMemoryLinksBase<TLink> : DisposableBase, ILinks<TLink>
16     {
17         private static readonly EqualityComparer<TLink> _equalityComparer =
18             ↪ EqualityComparer<TLink>.Default;
19         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
20         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
21             ↪ UncheckedConverter<TLink, long>.Default;
22         private static readonly UncheckedConverter<long, TLink> _int64ToAddressConverter =
23             ↪ UncheckedConverter<long, TLink>.Default;
24
25         private static readonly TLink _zero = default;
26         private static readonly TLink _one = Arithmetic.Increment(_zero);
27
28         /// <summary>Возвращает размер одной связи в байтах.</summary>
29         /// <remarks>
30         /// Используется только во вне класса, не рекомендуется использовать внутри.
31         /// Так как во вне не обязательно будет доступен unsafe C#.
32         /// </remarks>
33         public static readonly long LinkDataPartSizeInBytes = RawLinkDataPart<TLink>.SizeInBytes;
34
35         public static readonly long LinkIndexPartSizeInBytes =
36             ↪ RawLinkIndexPart<TLink>.SizeInBytes;
37
38         public static readonly long LinkHeaderSizeInBytes = LinksHeader<TLink>.SizeInBytes;
39
40         public static readonly long DefaultLinksSizeStep = 1 * 1024 * 1024;
41
42         protected readonly IResizableDirectMemory _dataMemory;
43         protected readonly IResizableDirectMemory _indexMemory;
44         protected readonly long _dataMemoryReservationStepInBytes;
45         protected readonly long _indexMemoryReservationStepInBytes;
46
47         protected ILinksTreeMethods<TLink> InternalSourcesTreeMethods;
48         protected ILinksTreeMethods<TLink> ExternalSourcesTreeMethods;
49         protected ILinksTreeMethods<TLink> InternalTargetsTreeMethods;
50         protected ILinksTreeMethods<TLink> ExternalTargetsTreeMethods;
51         // TODO: Возможно чтобы гарантированно проверять на то, является ли связь удалённой,
52         ↪ нужно использовать не список а дерево, так как так можно быстрее проверить на
53         ↪ наличие связи внутри
54         protected ILinksListMethods<TLink> UnusedLinksListMethods;
55
56         /// <summary>
57         /// Возвращает общее число связей находящихся в хранилище.
58         /// </summary>
59         protected virtual TLink Total
60         {
61             [MethodImpl(MethodImplOptions.AggressiveInlining)]
62             get
63             {
64                 ref var header = ref GetHeaderReference();
65                 return Subtract(header.AllocatedLinks, header.FreeLinks);
66             }
67         }
68
69         public virtual LinksConstants<TLink> Constants
70         {
71             [MethodImpl(MethodImplOptions.AggressiveInlining)]
72             get;
73         }
74     }
75 }

```

```

69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 protected SplitMemoryLinksBase(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants)
71 {
72     _dataMemory = dataMemory;
73     _indexMemory = indexMemory;
74     _dataMemoryReservationStepInBytes = memoryReservationStep * LinkDataPartSizeInBytes;
75     _indexMemoryReservationStepInBytes = memoryReservationStep *
    ↪ LinkIndexPartSizeInBytes;
76     Constants = constants;
77 }
78
79 [MethodImpl(MethodImplOptions.AggressiveInlining)]
80 protected SplitMemoryLinksBase(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↪ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
    ↪ memoryReservationStep, Default<LinksConstants<TLink>>.Instance) { }
81
82 [MethodImpl(MethodImplOptions.AggressiveInlining)]
83 protected virtual void Init(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↪ indexMemory)
84 {
85     if (dataMemory.ReservedCapacity < _dataMemoryReservationStepInBytes)
86     {
87         dataMemory.ReservedCapacity = _dataMemoryReservationStepInBytes;
88     }
89     if (indexMemory.ReservedCapacity < _indexMemoryReservationStepInBytes)
90     {
91         indexMemory.ReservedCapacity = _indexMemoryReservationStepInBytes;
92     }
93     SetPointers(dataMemory, indexMemory);
94     ref var header = ref GetHeaderReference();
95     // Ensure correctness _memory.UsedCapacity over _header->AllocatedLinks
96     // Гарантия корректности _memory.UsedCapacity относительно _header->AllocatedLinks
97     dataMemory.UsedCapacity = (ConvertToInt64(header.AllocatedLinks) *
    ↪ LinkDataPartSizeInBytes) + LinkDataPartSizeInBytes; // First link is read only
    ↪ zero link.
98     indexMemory.UsedCapacity = (ConvertToInt64(header.AllocatedLinks) *
    ↪ LinkIndexPartSizeInBytes) + LinkHeaderSizeInBytes;
99     // Ensure correctness _memory.ReservedLinks over _header->ReservedCapacity
100    // Гарантия корректности _header->ReservedLinks относительно _memory.ReservedCapacity
101    header.ReservedLinks = ConvertToAddress((dataMemory.ReservedCapacity -
    ↪ LinkDataPartSizeInBytes) / LinkDataPartSizeInBytes);
102 }
103
104 [MethodImpl(MethodImplOptions.AggressiveInlining)]
105 public virtual TLink Count(IList<TLink> restrictions)
106 {
107     // Если нет ограничений, тогда возвращаем общее число связей находящихся в хранилище.
108     if (restrictions.Count == 0)
109     {
110         return Total;
111     }
112     var constants = Constants;
113     var any = constants.Any;
114     var index = restrictions[constants.IndexPart];
115     if (restrictions.Count == 1)
116     {
117         if (AreEqual(index, any))
118         {
119             return Total;
120         }
121         return Exists(index) ? GetOne() : GetZero();
122     }
123     if (restrictions.Count == 2)
124     {
125         var value = restrictions[1];
126         if (AreEqual(index, any))
127         {
128             if (AreEqual(value, any))
129             {
130                 return Total; // Any - как отсутствие ограничения
131             }
132             var externalReferencesRange = constants.ExternalReferencesRange;
133             if (externalReferencesRange.HasValue &&
    ↪ externalReferencesRange.Value.Contains(value))
134             {
135                 return Add(ExternalSourcesTreeMethods.CountUsages(value),
    ↪ ExternalTargetsTreeMethods.CountUsages(value));

```

```

136     }
137     else
138     {
139         return Add(InternalSourcesTreeMethods.CountUsages(value),
140             ↪ InternalTargetsTreeMethods.CountUsages(value));
141     }
142 else
143 {
144     if (!Exists(index))
145     {
146         return GetZero();
147     }
148     if (AreEqual(value, any))
149     {
150         return GetOne();
151     }
152     ref var storedLinkValue = ref GetLinkDataPartReference(index);
153     if (AreEqual(storedLinkValue.Source, value) ||
154         ↪ AreEqual(storedLinkValue.Target, value))
155     {
156         return GetOne();
157     }
158     return GetZero();
159 }
160 if (restrictions.Count == 3)
161 {
162     var externalReferencesRange = constants.ExternalReferencesRange;
163     var source = restrictions[constants.SourcePart];
164     var target = restrictions[constants.TargetPart];
165     if (AreEqual(index, any))
166     {
167         if (AreEqual(source, any) && AreEqual(target, any))
168         {
169             return Total;
170         }
171         else if (AreEqual(source, any))
172         {
173             if (externalReferencesRange.HasValue &&
174                 ↪ externalReferencesRange.Value.Contains(target))
175             {
176                 return ExternalTargetsTreeMethods.CountUsages(target);
177             }
178             else
179             {
180                 return InternalTargetsTreeMethods.CountUsages(target);
181             }
182         }
183         else if (AreEqual(target, any))
184         {
185             if (externalReferencesRange.HasValue &&
186                 ↪ externalReferencesRange.Value.Contains(source))
187             {
188                 return ExternalSourcesTreeMethods.CountUsages(source);
189             }
190             else
191             {
192                 return InternalSourcesTreeMethods.CountUsages(source);
193             }
194         }
195         else //if(source != Any && target != Any)
196         {
197             // ЭКВИВАЛЕНТ Exists(source, target) => Count(Any, source, target) > 0
198             TLink link;
199             if (externalReferencesRange.HasValue)
200             {
201                 if (externalReferencesRange.Value.Contains(source) &&
202                     ↪ externalReferencesRange.Value.Contains(target))
203                 {
204                     link = ExternalSourcesTreeMethods.Search(source, target);
205                 }
206                 else if (externalReferencesRange.Value.Contains(source))
207                 {
208                     link = InternalTargetsTreeMethods.Search(source, target);
209                 }
210                 else if (externalReferencesRange.Value.Contains(target))
211                 {
212                     link = InternalSourcesTreeMethods.Search(source, target);
213                 }
214             }
215             else
216             {
217                 link = InternalTargetsTreeMethods.Search(source, target);
218             }
219         }
220     }
221 }

```

```

209         link = InternalSourcesTreeMethods.Search(source, target);
210     }
211     else
212     {
213         if (GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
214             ↪ InternalTargetsTreeMethods.CountUsages(target)))
215         {
216             link = InternalTargetsTreeMethods.Search(source, target);
217         }
218         else
219         {
220             link = InternalSourcesTreeMethods.Search(source, target);
221         }
222     }
223     else
224     {
225         if (GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
226             ↪ InternalTargetsTreeMethods.CountUsages(target)))
227         {
228             link = InternalTargetsTreeMethods.Search(source, target);
229         }
230         else
231         {
232             link = InternalSourcesTreeMethods.Search(source, target);
233         }
234     }
235     return AreEqual(link, constants.Null) ? GetZero() : GetOne();
236 }
237 else
238 {
239     if (!Exists(index))
240     {
241         return GetZero();
242     }
243     if (AreEqual(source, any) && AreEqual(target, any))
244     {
245         return GetOne();
246     }
247     ref var storedLinkValue = ref GetLinkDataPartReference(index);
248     if (!AreEqual(source, any) && !AreEqual(target, any))
249     {
250         if (AreEqual(storedLinkValue.Source, source) &&
251             ↪ AreEqual(storedLinkValue.Target, target))
252         {
253             return GetOne();
254         }
255         return GetZero();
256     }
257     var value = default(TLink);
258     if (AreEqual(source, any))
259     {
260         value = target;
261     }
262     if (AreEqual(target, any))
263     {
264         value = source;
265     }
266     if (AreEqual(storedLinkValue.Source, value) ||
267         ↪ AreEqual(storedLinkValue.Target, value))
268     {
269         return GetOne();
270     }
271     return GetZero();
272 }
273 }
274
275 throw new NotSupportedException("Другие размеры и способы ограничений не
276     ↪ поддерживаются.");
277 }
278
279 [MethodImpl(MethodImplOptions.AggressiveInlining)]
280 public virtual TLink Each(Func<IList<TLink>, TLink> handler, IList<TLink> restrictions)
281 {
282     var constants = Constants;
283     var @break = constants.Break;
284     if (restrictions.Count == 0)
285     {

```

```

282     for (var link = GetOne(); LessOrEqualThan(link,
283         ↪ GetHeaderReference().AllocatedLinks); link = Increment(link))
284     {
285         if (Exists(link) && AreEqual(handler(GetLinkStruct(link)), @break))
286         {
287             return @break;
288         }
289     }
290     return @break;
291 }
292 var @continue = constants.Continue;
293 var any = constants.Any;
294 var index = restrictions[constants.IndexPart];
295 if (restrictions.Count == 1)
296 {
297     if (AreEqual(index, any))
298     {
299         return Each(handler, Array.Empty<TLink>());
300     }
301     if (!Exists(index))
302     {
303         return @continue;
304     }
305     return handler(GetLinkStruct(index));
306 }
307 if (restrictions.Count == 2)
308 {
309     var value = restrictions[1];
310     if (AreEqual(index, any))
311     {
312         if (AreEqual(value, any))
313         {
314             return Each(handler, Array.Empty<TLink>());
315         }
316         if (AreEqual(Each(handler, new Link<TLink>(index, value, any)), @break))
317         {
318             return @break;
319         }
320         return Each(handler, new Link<TLink>(index, any, value));
321     }
322     else
323     {
324         if (!Exists(index))
325         {
326             return @continue;
327         }
328         if (AreEqual(value, any))
329         {
330             return handler(GetLinkStruct(index));
331         }
332         ref var storedLinkValue = ref GetLinkDataPartReference(index);
333         if (AreEqual(storedLinkValue.Source, value) ||
334             AreEqual(storedLinkValue.Target, value))
335         {
336             return handler(GetLinkStruct(index));
337         }
338         return @continue;
339     }
340 }
341 if (restrictions.Count == 3)
342 {
343     var externalReferencesRange = constants.ExternalReferencesRange;
344     var source = restrictions[constants.SourcePart];
345     var target = restrictions[constants.TargetPart];
346     if (AreEqual(index, any))
347     {
348         if (AreEqual(source, any) && AreEqual(target, any))
349         {
350             return Each(handler, Array.Empty<TLink>());
351         }
352         else if (AreEqual(source, any))
353         {
354             if (externalReferencesRange.HasValue &&
355                 ↪ externalReferencesRange.Value.Contains(target))
356             {
357                 return ExternalTargetsTreeMethods.EachUsage(target, handler);
358             }
359             else

```

```

358         {
359             return InternalTargetsTreeMethods.EachUsage(target, handler);
360         }
361     }
362     else if (AreEqual(target, any))
363     {
364         if (externalReferencesRange.HasValue &&
365             ↪ externalReferencesRange.Value.Contains(source))
366         {
367             return ExternalSourcesTreeMethods.EachUsage(source, handler);
368         }
369         else
370         {
371             return InternalSourcesTreeMethods.EachUsage(source, handler);
372         }
373     }
374     else //if(source != Any && target != Any)
375     {
376         TLink link;
377         if (externalReferencesRange.HasValue)
378         {
379             if (externalReferencesRange.Value.Contains(source) &&
380                 ↪ externalReferencesRange.Value.Contains(target))
381             {
382                 link = ExternalSourcesTreeMethods.Search(source, target);
383             }
384             else if (externalReferencesRange.Value.Contains(source))
385             {
386                 link = InternalTargetsTreeMethods.Search(source, target);
387             }
388             else if (externalReferencesRange.Value.Contains(target))
389             {
390                 link = InternalSourcesTreeMethods.Search(source, target);
391             }
392             else
393             {
394                 if (GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
395                     ↪ InternalTargetsTreeMethods.CountUsages(target)))
396                 {
397                     link = InternalTargetsTreeMethods.Search(source, target);
398                 }
399                 else
400                 {
401                     link = InternalSourcesTreeMethods.Search(source, target);
402                 }
403             }
404         }
405         else
406         {
407             if (GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
408                 ↪ InternalTargetsTreeMethods.CountUsages(target)))
409             {
410                 link = InternalTargetsTreeMethods.Search(source, target);
411             }
412             else
413             {
414                 link = InternalSourcesTreeMethods.Search(source, target);
415             }
416         }
417         return AreEqual(link, constants.Null) ? @continue :
418             ↪ handler(GetLinkStruct(link));
419     }
420 }
421 else
422 {
423     if (!Exists(index))
424     {
425         return @continue;
426     }
427     if (AreEqual(source, any) && AreEqual(target, any))
428     {
429         return handler(GetLinkStruct(index));
430     }
431     ref var storedLinkValue = ref GetLinkDataPartReference(index);
432     if (!AreEqual(source, any) && !AreEqual(target, any))
433     {
434         if (AreEqual(storedLinkValue.Source, source) &&
435             AreEqual(storedLinkValue.Target, target))

```

```

431         {
432             return handler(GetLinkStruct(index));
433         }
434         return @continue;
435     }
436     var value = default(TLink);
437     if (AreEqual(source, any))
438     {
439         value = target;
440     }
441     if (AreEqual(target, any))
442     {
443         value = source;
444     }
445     if (AreEqual(storedLinkValue.Source, value) ||
446         AreEqual(storedLinkValue.Target, value))
447     {
448         return handler(GetLinkStruct(index));
449     }
450     return @continue;
451 }
452 }
453 throw new NotSupportedException("Другие размеры и способы ограничений не
    ↳ поддерживаются.");
454 }
455
456 /// <remarks>
457 /// TODO: Возможно можно перемещать значения, если указан индекс, но значение существует
458 /// ↳ в другом месте (но не в менеджере памяти, а в логике Links)
459 /// </remarks>
460 [MethodImpl(MethodImplOptions.AggressiveInlining)]
461 public virtual TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
462 {
463     var constants = Constants;
464     var @null = constants.Null;
465     var externalReferencesRange = constants.ExternalReferencesRange;
466     var linkIndex = restrictions[constants.IndexPart];
467     ref var link = ref GetLinkDataPartReference(linkIndex);
468     var source = link.Source;
469     var target = link.Target;
470     ref var header = ref GetHeaderReference();
471     ref var rootAsSource = ref header.RootAsSource;
472     ref var rootAsTarget = ref header.RootAsTarget;
473     // Будет корректно работать только в том случае, если пространство выделенной связи
474     // ↳ предварительно заполнено нулями
475     if (!AreEqual(source, @null))
476     {
477         if (externalReferencesRange.HasValue &&
478             ↳ externalReferencesRange.Value.Contains(source))
479         {
480             ExternalSourcesTreeMethods.Detach(ref rootAsSource, linkIndex);
481         }
482         else
483         {
484             InternalSourcesTreeMethods.Detach(ref
485                 ↳ GetLinkIndexPartReference(source).RootAsSource, linkIndex);
486         }
487     }
488     if (!AreEqual(target, @null))
489     {
490         if (externalReferencesRange.HasValue &&
491             ↳ externalReferencesRange.Value.Contains(target))
492         {
493             ExternalTargetsTreeMethods.Detach(ref rootAsTarget, linkIndex);
494         }
495         else
496         {
497             InternalTargetsTreeMethods.Detach(ref
498                 ↳ GetLinkIndexPartReference(target).RootAsTarget, linkIndex);
499         }
500     }
501     source = link.Source = substitution[constants.SourcePart];
502     target = link.Target = substitution[constants.TargetPart];
503     if (!AreEqual(source, @null))
504     {
505         if (externalReferencesRange.HasValue &&
506             ↳ externalReferencesRange.Value.Contains(source))
507         {

```



```

501         ExternalSourcesTreeMethods.Attach(ref rootAsSource, linkIndex);
502     }
503     else
504     {
505         InternalSourcesTreeMethods.Attach(ref
506             ↪ GetLinkIndexPartReference(source).RootAsSource, linkIndex);
507     }
508     if (!AreEqual(target, @null))
509     {
510         if (externalReferencesRange.HasValue &&
511             ↪ externalReferencesRange.Value.Contains(target))
512         {
513             ExternalTargetsTreeMethods.Attach(ref rootAsTarget, linkIndex);
514         }
515         else
516         {
517             InternalTargetsTreeMethods.Attach(ref
518                 ↪ GetLinkIndexPartReference(target).RootAsTarget, linkIndex);
519         }
520     }
521     return linkIndex;
522 }
523
524 /// <remarks>
525 /// TODO: Возможно нужно будет заполнение нулями, если внешнее API ими не заполняет
526 ↪ пространство
527 /// </remarks>
528 [MethodImpl(MethodImplOptions.AggressiveInlining)]
529 public virtual TLink Create(ICollection<TLink> restrictions)
530 {
531     ref var header = ref GetHeaderReference();
532     var freeLink = header.FirstFreeLink;
533     if (!AreEqual(freeLink, Constants.Null))
534     {
535         UnusedLinksListMethods.Detach(freeLink);
536     }
537     else
538     {
539         var maximumPossibleInnerReference = Constants.InternalReferencesRange.Maximum;
540         if (GreaterThan(header.AllocatedLinks, maximumPossibleInnerReference))
541         {
542             throw new LinksLimitReachedException<TLink>(maximumPossibleInnerReference);
543         }
544         if (GreaterOrEqualThan(header.AllocatedLinks, Decrement(header.ReservedLinks)))
545         {
546             _dataMemory.ReservedCapacity += _dataMemory.ReservationStepInBytes;
547             _indexMemory.ReservedCapacity += _indexMemory.ReservationStepInBytes;
548             SetPointers(_dataMemory, _indexMemory);
549             header = ref GetHeaderReference();
550             header.ReservedLinks = ConvertToAddress(_dataMemory.ReservedCapacity /
551                 ↪ LinkDataPartSizeInBytes);
552         }
553         header.AllocatedLinks = Increment(header.AllocatedLinks);
554         _dataMemory.UsedCapacity += LinkDataPartSizeInBytes;
555         _indexMemory.UsedCapacity += LinkIndexPartSizeInBytes;
556         freeLink = header.AllocatedLinks;
557     }
558     return freeLink;
559 }
560
561 [MethodImpl(MethodImplOptions.AggressiveInlining)]
562 public virtual void Delete(ICollection<TLink> restrictions)
563 {
564     ref var header = ref GetHeaderReference();
565     var link = restrictions[Constants.IndexPart];
566     if (LessThan(link, header.AllocatedLinks))
567     {
568         UnusedLinksListMethods.AttachAsFirst(link);
569     }
570     else if (AreEqual(link, header.AllocatedLinks))
571     {
572         header.AllocatedLinks = Decrement(header.AllocatedLinks);
573         _dataMemory.UsedCapacity -= LinkDataPartSizeInBytes;
574         _indexMemory.UsedCapacity -= LinkIndexPartSizeInBytes;
575         // Убираем все связи, находящиеся в списке свободных в конце файла, до тех пор,
576         ↪ пока не дойдём до первой существующей связи
577         // Позволяет оптимизировать количество выделенных связей (AllocatedLinks)

```

```

573         while (GreaterThan(header.AllocatedLinks, GetZero()) &&
574             ↪ IsUnusedLink(header.AllocatedLinks))
575         {
576             UnusedLinksListMethods.Detach(header.AllocatedLinks);
577             header.AllocatedLinks = Decrement(header.AllocatedLinks);
578             _dataMemory.UsedCapacity -= LinkDataPartSizeInBytes;
579             _indexMemory.UsedCapacity -= LinkIndexPartSizeInBytes;
580         }
581     }
582
583     [MethodImpl(MethodImplOptions.AggressiveInlining)]
584     public IList<TLink> GetLinkStruct(TLink linkIndex)
585     {
586         ref var link = ref GetLinkDataPartReference(linkIndex);
587         return new Link<TLink>(linkIndex, link.Source, link.Target);
588     }
589
590     /// <remarks>
591     /// TODO: Возможно это должно быть событием, вызываемым из IMemory, в том случае, если
592     /// ↪ адрес реально поменялся
593     ///
594     /// Указатель this.links может быть в том же месте,
595     /// так как 0-я связь не используется и имеет такой же размер как Header,
596     /// поэтому header размещается в том же месте, что и 0-я связь
597     /// </remarks>
598     [MethodImpl(MethodImplOptions.AggressiveInlining)]
599     protected abstract void SetPointers(IResizableDirectMemory dataMemory,
600     ↪ IResizableDirectMemory indexMemory);
601
602     [MethodImpl(MethodImplOptions.AggressiveInlining)]
603     protected virtual void ResetPointers()
604     {
605         InternalSourcesTreeMethods = null;
606         ExternalSourcesTreeMethods = null;
607         InternalTargetsTreeMethods = null;
608         ExternalTargetsTreeMethods = null;
609         UnusedLinksListMethods = null;
610     }
611
612     [MethodImpl(MethodImplOptions.AggressiveInlining)]
613     protected abstract ref LinksHeader<TLink> GetHeaderReference();
614
615     [MethodImpl(MethodImplOptions.AggressiveInlining)]
616     protected abstract ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex);
617
618     [MethodImpl(MethodImplOptions.AggressiveInlining)]
619     protected abstract ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
620     ↪ linkIndex);
621
622     [MethodImpl(MethodImplOptions.AggressiveInlining)]
623     protected virtual bool Exists(TLink link)
624     => GreaterOrEqualThan(link, Constants.InternalReferencesRange.Minimum)
625     && LessOrEqualThan(link, GetHeaderReference().AllocatedLinks)
626     && !IsUnusedLink(link);
627
628     [MethodImpl(MethodImplOptions.AggressiveInlining)]
629     protected virtual bool IsUnusedLink(TLink linkIndex)
630     {
631         if (!AreEqual(GetHeaderReference().FirstFreeLink, linkIndex)) // May be this check
632         ↪ is not needed
633         {
634             // TODO: Reduce access to memory in different location (should be enough to use
635             ↪ just linkIndexPart)
636             ref var linkDataPart = ref GetLinkDataPartReference(linkIndex);
637             ref var linkIndexPart = ref GetLinkIndexPartReference(linkIndex);
638             return AreEqual(linkIndexPart.SizeAsSource, default) &&
639             ↪ !AreEqual(linkDataPart.Source, default);
640         }
641         else
642         {
643             return true;
644         }
645     }
646
647     [MethodImpl(MethodImplOptions.AggressiveInlining)]
648     protected virtual TLink GetOne() => _one;
649
650     [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

645     protected virtual TLink GetZero() => default;
646
647     [MethodImpl(MethodImplOptions.AggressiveInlining)]
648     protected virtual bool AreEqual(TLink first, TLink second) =>
        ↳ _equalityComparer.Equals(first, second);
649
650     [MethodImpl(MethodImplOptions.AggressiveInlining)]
651     protected virtual bool LessThan(TLink first, TLink second) => _comparer.Compare(first,
        ↳ second) < 0;
652
653     [MethodImpl(MethodImplOptions.AggressiveInlining)]
654     protected virtual bool LessOrEqualThan(TLink first, TLink second) =>
        ↳ _comparer.Compare(first, second) <= 0;
655
656     [MethodImpl(MethodImplOptions.AggressiveInlining)]
657     protected virtual bool GreaterThan(TLink first, TLink second) =>
        ↳ _comparer.Compare(first, second) > 0;
658
659     [MethodImpl(MethodImplOptions.AggressiveInlining)]
660     protected virtual bool GreaterOrEqualThan(TLink first, TLink second) =>
        ↳ _comparer.Compare(first, second) >= 0;
661
662     [MethodImpl(MethodImplOptions.AggressiveInlining)]
663     protected virtual long ConvertToInt64(TLink value) =>
        ↳ _addressToInt64Converter.Convert(value);
664
665     [MethodImpl(MethodImplOptions.AggressiveInlining)]
666     protected virtual TLink ConvertToAddress(long value) =>
        ↳ _int64ToAddressConverter.Convert(value);
667
668     [MethodImpl(MethodImplOptions.AggressiveInlining)]
669     protected virtual TLink Add(TLink first, TLink second) => Arithmetic<TLink>.Add(first,
        ↳ second);
670
671     [MethodImpl(MethodImplOptions.AggressiveInlining)]
672     protected virtual TLink Subtract(TLink first, TLink second) =>
        ↳ Arithmetic<TLink>.Subtract(first, second);
673
674     [MethodImpl(MethodImplOptions.AggressiveInlining)]
675     protected virtual TLink Increment(TLink link) => Arithmetic<TLink>.Increment(link);
676
677     [MethodImpl(MethodImplOptions.AggressiveInlining)]
678     protected virtual TLink Decrement(TLink link) => Arithmetic<TLink>.Decrement(link);
679
680     #region Disposable
681
682     protected override bool AllowMultipleDisposeCalls
683     {
684         [MethodImpl(MethodImplOptions.AggressiveInlining)]
685         get => true;
686     }
687
688     [MethodImpl(MethodImplOptions.AggressiveInlining)]
689     protected override void Dispose(bool manual, bool wasDisposed)
690     {
691         if (!wasDisposed)
692         {
693             ResetPointers();
694             _dataMemory.DisposeIfPossible();
695             _indexMemory.DisposeIfPossible();
696         }
697     }
698
699     #endregion
700 }
701 }

```

1.38 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/UnusedLinksListMethods.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Collections.Methods.Lists;
3  using Platform.Converters;
4  using static System.Runtime.CompilerServices.Unsafe;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Memory.Split.Generic
9  {
10     public unsafe class UnusedLinksListMethods<TLink> : CircularDoublyLinkedListMethods<TLink>,
        ↳ ILinksListMethods<TLink>

```

```

11 {
12     private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
13         ↪ UncheckedConverter<TLink, long>.Default;
14
15     private readonly byte* _links;
16     private readonly byte* _header;
17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     public UnusedLinksListMethods(byte* links, byte* header)
20     {
21         _links = links;
22         _header = header;
23     }
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
27         ↪ AsRef<LinksHeader<TLink>>(_header);
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
31         ↪ AsRef<RawLinkDataPart<TLink>>(_links + (RawLinkDataPart<TLink>.SizeInBytes *
32         ↪ _addressToInt64Converter.Convert(link)));
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override TLink GetFirst() => GetHeaderReference().FirstFreeLink;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override TLink GetLast() => GetHeaderReference().LastFreeLink;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetPrevious(TLink element) =>
42         ↪ GetLinkDataPartReference(element).Source;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override TLink GetNext(TLink element) =>
46         ↪ GetLinkDataPartReference(element).Target;
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override TLink GetSize() => GetHeaderReference().FreeLinks;
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override void SetFirst(TLink element) => GetHeaderReference().FirstFreeLink =
53         ↪ element;
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override void SetLast(TLink element) => GetHeaderReference().LastFreeLink =
57         ↪ element;
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     protected override void SetPrevious(TLink element, TLink previous) =>
61         ↪ GetLinkDataPartReference(element).Source = previous;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override void SetNext(TLink element, TLink next) =>
65         ↪ GetLinkDataPartReference(element).Target = next;
66
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     protected override void SetSize(TLink size) => GetHeaderReference().FreeLinks = size;
69 }
70 }

```

1.39 ./csharp/Platform.Data.Doublets/Memory/Split/RawLinkDataPart.cs

```

1 using Platform.Unsafe;
2 using System;
3 using System.Collections.Generic;
4 using System.Runtime.CompilerServices;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Memory.Split
9 {
10     public struct RawLinkDataPart<TLink> : IEquatable<RawLinkDataPart<TLink>>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
13             ↪ EqualityComparer<TLink>.Default;
14
15         public static readonly long SizeInBytes = Structure<RawLinkDataPart<TLink>>.Size;
16
17         public TLink Source;
18         public TLink Target;
19     }
20 }

```

```

18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     public override bool Equals(object obj) => obj is RawLinkDataPart<TLink> link ?
20         ↳ Equals(link) : false;
21
22     [MethodImpl(MethodImplOptions.AggressiveInlining)]
23     public bool Equals(RawLinkDataPart<TLink> other)
24         => _equalityComparer.Equals(Source, other.Source)
25         && _equalityComparer.Equals(Target, other.Target);
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     public override int GetHashCode() => (Source, Target).GetHashCode();
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     public static bool operator ==(RawLinkDataPart<TLink> left, RawLinkDataPart<TLink>
32         ↳ right) => left.Equals(right);
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     public static bool operator !=(RawLinkDataPart<TLink> left, RawLinkDataPart<TLink>
36         ↳ right) => !(left == right);
37 }
38 }

```

1.40 ./csharp/Platform.Data.Doublets/Memory/Split/RawLinkIndexPart.cs

```

1  using Platform.Unsafe;
2  using System;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Memory.Split
9  {
10     public struct RawLinkIndexPart<TLink> : IEquatable<RawLinkIndexPart<TLink>>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
13             ↳ EqualityComparer<TLink>.Default;
14
15         public static readonly long SizeInBytes = Structure<RawLinkIndexPart<TLink>>.Size;
16
17         public TLink RootAsSource;
18         public TLink LeftAsSource;
19         public TLink RightAsSource;
20         public TLink SizeAsSource;
21         public TLink RootAsTarget;
22         public TLink LeftAsTarget;
23         public TLink RightAsTarget;
24         public TLink SizeAsTarget;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public override bool Equals(object obj) => obj is RawLinkIndexPart<TLink> link ?
28             ↳ Equals(link) : false;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public bool Equals(RawLinkIndexPart<TLink> other)
32             => _equalityComparer.Equals(RootAsSource, other.RootAsSource)
33             && _equalityComparer.Equals(LeftAsSource, other.LeftAsSource)
34             && _equalityComparer.Equals(RightAsSource, other.RightAsSource)
35             && _equalityComparer.Equals(SizeAsSource, other.SizeAsSource)
36             && _equalityComparer.Equals(RootAsTarget, other.RootAsTarget)
37             && _equalityComparer.Equals(LeftAsTarget, other.LeftAsTarget)
38             && _equalityComparer.Equals(RightAsTarget, other.RightAsTarget)
39             && _equalityComparer.Equals(SizeAsTarget, other.SizeAsTarget);
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         public override int GetHashCode() => (RootAsSource, LeftAsSource, RightAsSource,
43             ↳ SizeAsSource, RootAsTarget, LeftAsTarget, RightAsTarget, SizeAsTarget).GetHashCode();
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public static bool operator ==(RawLinkIndexPart<TLink> left, RawLinkIndexPart<TLink>
47             ↳ right) => left.Equals(right);
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         public static bool operator !=(RawLinkIndexPart<TLink> left, RawLinkIndexPart<TLink>
51             ↳ right) => !(left == right);
52     }
53 }

```



```

73     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
74         ↪ ref LinksDataParts[link];
75
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
78         ↪ ref LinksIndexParts[link];
79
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
82     {
83         ref var firstLink = ref LinksDataParts[first];
84         ref var secondLink = ref LinksDataParts[second];
85         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
86             ↪ secondLink.Source, secondLink.Target);
87     }
88
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
91     {
92         ref var firstLink = ref LinksDataParts[first];
93         ref var secondLink = ref LinksDataParts[second];
94         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
95             ↪ secondLink.Source, secondLink.Target);
96     }
97 }
98
99 }

```

1.42 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksSourcesSizeBalancedTreeMetho

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt32;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt32ExternalLinksSourcesSizeBalancedTreeMethods :
9          ↪ UInt32ExternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt32ExternalLinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink>
13             ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14             ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15             ↪ linksIndexParts, header) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref TLink GetLeftReference(TLink node) => ref
19             ↪ LinksIndexParts[node].LeftAsSource;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref TLink GetRightReference(TLink node) => ref
23             ↪ LinksIndexParts[node].RightAsSource;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsSource;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsSource;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33             ↪ LinksIndexParts[node].LeftAsSource = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37             ↪ LinksIndexParts[node].RightAsSource = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override void SetSize(TLink node, TLink size) =>
44             ↪ LinksIndexParts[node].SizeAsSource = size;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetTreeRoot() => Header->RootAsSource;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
51
52     }
53 }

```

```

43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override bool FirstIsToLeftOfSecond(TLink firstSource, TLink firstTarget,
45         ↪ TLink secondSource, TLink secondTarget)
46         => firstSource < secondSource || firstSource == secondSource && firstTarget <
47         ↪ secondTarget;
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
51         ↪ TLink secondSource, TLink secondTarget)
52         => firstSource > secondSource || firstSource == secondSource && firstTarget >
53         ↪ secondTarget;
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override void ClearNode(TLink node)
57     {
58         ref var link = ref LinksIndexParts[node];
59         link.LeftAsSource = Zero;
60         link.RightAsSource = Zero;
61         link.SizeAsSource = Zero;
62     }
63 }

```

1.43 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksTargetsSizeBalancedTreeMethods

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt32;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt32ExternalLinksTargetsSizeBalancedTreeMethods :
9          ↪ UInt32ExternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt32ExternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink>
13             ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14             ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15             ↪ linksIndexParts, header) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref TLink GetLeftReference(TLink node) => ref
19             ↪ LinksIndexParts[node].LeftAsTarget;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref TLink GetRightReference(TLink node) => ref
23             ↪ LinksIndexParts[node].RightAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33             ↪ LinksIndexParts[node].LeftAsTarget = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37             ↪ LinksIndexParts[node].RightAsTarget = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override void SetSize(TLink node, TLink size) =>
44             ↪ LinksIndexParts[node].SizeAsTarget = size;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetTreeRoot() => Header->RootAsTarget;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]
53         protected override bool FirstIsToLeftOfSecond(TLink firstSource, TLink firstTarget,
54             ↪ TLink secondSource, TLink secondTarget)
55
56     }
57 }

```



```

45     => firstTarget < secondTarget || firstTarget == secondTarget && firstSource <
        ↳ secondSource;
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
        ↳ TLink secondSource, TLink secondTarget)
49         => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
        ↳ secondSource;
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override void ClearNode(TLink node)
53     {
54         ref var link = ref LinksIndexParts[node];
55         link.LeftAsTarget = Zero;
56         link.RightAsTarget = Zero;
57         link.SizeAsTarget = Zero;
58     }
59 }
60 }

```

1.44 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSizeBalancedTreeMethodsBase

```

1  using System.Runtime.CompilerServices;
2  using Platform.Data.Doublets.Memory.Split.Generic;
3  using TLink = System.UInt32;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Memory.Split.Specific
8  {
9      public unsafe abstract class UInt32InternalLinksSizeBalancedTreeMethodsBase :
        ↳ InternalLinksSizeBalancedTreeMethodsBase<TLink>
10     {
11         protected new readonly RawLinkDataPart<TLink>* LinksDataParts;
12         protected new readonly RawLinkIndexPart<TLink>* LinksIndexParts;
13         protected new readonly LinksHeader<TLink>* Header;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         protected UInt32InternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink>
        ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
        ↳ linksIndexParts, LinksHeader<TLink>* header)
17             : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
18         {
19             LinksDataParts = linksDataParts;
20             LinksIndexParts = linksIndexParts;
21             Header = header;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected override TLink GetZero() => 0U;
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         protected override bool EqualToZero(TLink value) => value == 0U;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         protected override bool AreEqual(TLink first, TLink second) => first == second;
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         protected override bool GreaterThanZero(TLink value) => value > 0U;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override bool GreaterThan(TLink first, TLink second) => first > second;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override bool GreaterOrEqualThanZero(TLink value) => true; // value >= 0 is
        ↳ always true for ulong
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected override bool LessOrEqualThanZero(TLink value) => value == 0UL; // value is
        ↳ always >= 0 for ulong
47
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override bool LessThanZero(TLink value) => false; // value < 0 is always false
        ↳ for ulong
53

```

```

54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override bool LessThan(TLink first, TLink second) => first < second;
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override TLink Increment(TLink value) => ++value;
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override TLink Decrement(TLink value) => --value;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override TLink Add(TLink first, TLink second) => first + second;
65
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     protected override TLink Subtract(TLink first, TLink second) => first - second;
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
71     ↪ ref LinksDataParts[link];
72
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
75     ↪ ref LinksIndexParts[link];
76
77     [MethodImpl(MethodImplOptions.AggressiveInlining)]
78     protected override bool FirstIsToLeftOfSecond(TLink first, TLink second) =>
79     ↪ GetKeyPartValue(first) < GetKeyPartValue(second);
80
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     protected override bool FirstIsToRightOfSecond(TLink first, TLink second) =>
83     ↪ GetKeyPartValue(first) > GetKeyPartValue(second);
84 }
85 }

```

1.45 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSourcesSizeBalancedTreeMethods

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt32;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt32InternalLinksSourcesSizeBalancedTreeMethods :
9      ↪ UInt32InternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt32InternalLinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink>
13         ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14         ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15         ↪ linksIndexParts, header) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref TLink GetLeftReference(TLink node) => ref
19         ↪ LinksIndexParts[node].LeftAsSource;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref TLink GetRightReference(TLink node) => ref
23         ↪ LinksIndexParts[node].RightAsSource;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsSource;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsSource;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33         ↪ LinksIndexParts[node].LeftAsSource = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37         ↪ LinksIndexParts[node].RightAsSource = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override void SetSize(TLink node, TLink size) =>
44         ↪ LinksIndexParts[node].SizeAsSource = size;
45     }
46 }

```

```

37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsSource;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Target;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override void ClearNode(TLink node)
48     {
49         ref var link = ref LinksIndexParts[node];
50         link.LeftAsSource = Zero;
51         link.RightAsSource = Zero;
52         link.SizeAsSource = Zero;
53     }
54
55     public override TLink Search(TLink source, TLink target) =>
56     ↪ SearchCore(GetTreeRoot(source), target);
57 }

```

1.46 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksTargetsSizeBalancedTreeMethod

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt32;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt32InternalLinksTargetsSizeBalancedTreeMethods :
9      ↪ UInt32InternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt32InternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink>
13             ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14             ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15             ↪ linksIndexParts, header) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref TLink GetLeftReference(TLink node) => ref
19             ↪ LinksIndexParts[node].LeftAsTarget;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref TLink GetRightReference(TLink node) => ref
23             ↪ LinksIndexParts[node].RightAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33             ↪ LinksIndexParts[node].LeftAsTarget = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37             ↪ LinksIndexParts[node].RightAsTarget = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override void SetSize(TLink node, TLink size) =>
44             ↪ LinksIndexParts[node].SizeAsTarget = size;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsTarget;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]
53         protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Source;
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     }
57 }

```

```

47     protected override void ClearNode(TLink node)
48     {
49         ref var link = ref LinksIndexParts[node];
50         link.LeftAsTarget = Zero;
51         link.RightAsTarget = Zero;
52         link.SizeAsTarget = Zero;
53     }
54
55     public override TLink Search(TLink source, TLink target) =>
56         ↪ SearchCore(GetTreeRoot(target), source);
57 }

```

1.47 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32SplitMemoryLinks.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Singletons;
4  using Platform.Memory;
5  using Platform.Data.Doublets.Memory.Split.Generic;
6  using TLink = System.UInt32;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Memory.Split.Specific
11 {
12     public unsafe class UInt32SplitMemoryLinks : SplitMemoryLinksBase<TLink>
13     {
14         private readonly Func<ILinksTreeMethods<TLink>> _createInternalSourceTreeMethods;
15         private readonly Func<ILinksTreeMethods<TLink>> _createExternalSourceTreeMethods;
16         private readonly Func<ILinksTreeMethods<TLink>> _createInternalTargetTreeMethods;
17         private readonly Func<ILinksTreeMethods<TLink>> _createExternalTargetTreeMethods;
18         private LinksHeader<TLink>* _header;
19         private RawLinkDataPart<TLink>* _linksDataParts;
20         private RawLinkIndexPart<TLink>* _linksIndexParts;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public UInt32SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
24             ↪ indexMemory) : this(dataMemory, indexMemory, DefaultLinksSizeStep) { }
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public UInt32SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
28             ↪ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
29             ↪ memoryReservationStep, Default<LinksConstants<TLink>>.Instance) { }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public UInt32SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
33             ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants) :
34             ↪ base(dataMemory, indexMemory, memoryReservationStep, constants)
35         {
36             _createInternalSourceTreeMethods = () => new
37                 ↪ UInt32InternalLinksSourcesSizeBalancedTreeMethods(Constants, _linksDataParts,
38                 ↪ _linksIndexParts, _header);
39             _createExternalSourceTreeMethods = () => new
40                 ↪ UInt32ExternalLinksSourcesSizeBalancedTreeMethods(Constants, _linksDataParts,
41                 ↪ _linksIndexParts, _header);
42             _createInternalTargetTreeMethods = () => new
43                 ↪ UInt32InternalLinksTargetsSizeBalancedTreeMethods(Constants, _linksDataParts,
44                 ↪ _linksIndexParts, _header);
45             _createExternalTargetTreeMethods = () => new
46                 ↪ UInt32ExternalLinksTargetsSizeBalancedTreeMethods(Constants, _linksDataParts,
47                 ↪ _linksIndexParts, _header);
48             Init(dataMemory, indexMemory);
49         }
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override void SetPointers(IResizableDirectMemory dataMemory,
53             ↪ IResizableDirectMemory indexMemory)
54         {
55             _linksDataParts = (RawLinkDataPart<TLink>*)dataMemory.Pointer;
56             _linksIndexParts = (RawLinkIndexPart<TLink>*)indexMemory.Pointer;
57             _header = (LinksHeader<TLink>*)indexMemory.Pointer;
58             InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
59             ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
60             InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
61             ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
62             UnusedLinksListMethods = new UInt32UnusedLinksListMethods(_linksDataParts, _header);
63         }
64
65         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

52     protected override void ResetPointers()
53     {
54         base.ResetPointers();
55         _linksDataParts = null;
56         _linksIndexParts = null;
57         _header = null;
58     }
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
65     ↪ => ref _linksDataParts[linkIndex];
66
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
69     ↪ linkIndex) => ref _linksIndexParts[linkIndex];
70
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     protected override bool AreEqual(TLink first, TLink second) => first == second;
73
74     [MethodImpl(MethodImplOptions.AggressiveInlining)]
75     protected override bool LessThan(TLink first, TLink second) => first < second;
76
77     [MethodImpl(MethodImplOptions.AggressiveInlining)]
78     protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;
79
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     protected override bool GreaterThan(TLink first, TLink second) => first > second;
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;
85
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     protected override TLink GetZero() => 0U;
88
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     protected override TLink GetOne() => 1U;
91
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     protected override long ConvertToInt64(TLink value) => value;
94
95     [MethodImpl(MethodImplOptions.AggressiveInlining)]
96     protected override TLink ConvertToAddress(long value) => (TLink)value;
97
98     [MethodImpl(MethodImplOptions.AggressiveInlining)]
99     protected override TLink Add(TLink first, TLink second) => first + second;
100
101     [MethodImpl(MethodImplOptions.AggressiveInlining)]
102     protected override TLink Subtract(TLink first, TLink second) => first - second;
103
104     [MethodImpl(MethodImplOptions.AggressiveInlining)]
105     protected override TLink Increment(TLink link) => ++link;
106
107     [MethodImpl(MethodImplOptions.AggressiveInlining)]
108     protected override TLink Decrement(TLink link) => --link;
109 }

```

1.48 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32UnusedLinksListMethods.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Data.Doublets.Memory.Split.Generic;
3  using TLink = System.UInt32;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Memory.Split.Specific
8  {
9      public unsafe class UInt32UnusedLinksListMethods : UnusedLinksListMethods<TLink>
10     {
11         private readonly RawLinkDataPart<TLink>* _links;
12         private readonly LinksHeader<TLink>* _header;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public UInt32UnusedLinksListMethods(RawLinkDataPart<TLink>* links, LinksHeader<TLink>*
16         ↪ header)
17         : base((byte*)links, (byte*)header)
18         {
19             _links = links;

```

```

19     _header = header;
20 }
21
22 [MethodImpl(MethodImplOptions.AggressiveInlining)]
23 protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
    ↳ ref _links[link];
24
25 [MethodImpl(MethodImplOptions.AggressiveInlining)]
26 protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
27 }
28 }

```

1.49 ./csharp/Platform.Data.Doublets.Memory.Split.Specific/UInt64ExternalLinksSizeBalancedTreeMethodsBase

```

1 using System.Runtime.CompilerServices;
2 using Platform.Data.Doublets.Memory.Split.Generic;
3 using TLink = System.UInt64;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Memory.Split.Specific
8 {
9     public unsafe abstract class UInt64ExternalLinksSizeBalancedTreeMethodsBase :
    ↳ ExternalLinksSizeBalancedTreeMethodsBase<TLink>, ILinksTreeMethods<TLink>
10    {
11        protected new readonly RawLinkDataPart<TLink>* LinksDataParts;
12        protected new readonly RawLinkIndexPart<TLink>* LinksIndexParts;
13        protected new readonly LinksHeader<TLink>* Header;
14
15        [MethodImpl(MethodImplOptions.AggressiveInlining)]
16        protected UInt64ExternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink>
    ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
    ↳ linksIndexParts, LinksHeader<TLink>* header)
    ↳ : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
17        {
18            LinksDataParts = linksDataParts;
19            LinksIndexParts = linksIndexParts;
20            Header = header;
21        }
22
23
24        [MethodImpl(MethodImplOptions.AggressiveInlining)]
25        protected override ulong GetZero() => OUL;
26
27        [MethodImpl(MethodImplOptions.AggressiveInlining)]
28        protected override bool EqualToZero(ulong value) => value == OUL;
29
30        [MethodImpl(MethodImplOptions.AggressiveInlining)]
31        protected override bool AreEqual(ulong first, ulong second) => first == second;
32
33        [MethodImpl(MethodImplOptions.AggressiveInlining)]
34        protected override bool GreaterThanZero(ulong value) => value > OUL;
35
36        [MethodImpl(MethodImplOptions.AggressiveInlining)]
37        protected override bool GreaterThan(ulong first, ulong second) => first > second;
38
39        [MethodImpl(MethodImplOptions.AggressiveInlining)]
40        protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
41
42        [MethodImpl(MethodImplOptions.AggressiveInlining)]
43        protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
    ↳ always true for ulong
44
45        [MethodImpl(MethodImplOptions.AggressiveInlining)]
46        protected override bool LessOrEqualThanZero(ulong value) => value == OUL; // value is
    ↳ always >= 0 for ulong
47
48        [MethodImpl(MethodImplOptions.AggressiveInlining)]
49        protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
50
51        [MethodImpl(MethodImplOptions.AggressiveInlining)]
52        protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
    ↳ for ulong
53
54        [MethodImpl(MethodImplOptions.AggressiveInlining)]
55        protected override bool LessThan(ulong first, ulong second) => first < second;
56
57        [MethodImpl(MethodImplOptions.AggressiveInlining)]
58        protected override ulong Increment(ulong value) => ++value;
59
60        [MethodImpl(MethodImplOptions.AggressiveInlining)]
61        protected override ulong Decrement(ulong value) => --value;

```

```

62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     protected override ulong Add(ulong first, ulong second) => first + second;
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override ulong Subtract(ulong first, ulong second) => first - second;
67
68     [MethodImpl(MethodImplOptions.AggressiveInlining)]
69     protected override ref TLink GetHeaderReference() => ref *Header;
70
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
73     ↪ ref LinksDataParts[link];
74
75     [MethodImpl(MethodImplOptions.AggressiveInlining)]
76     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
77     ↪ ref LinksIndexParts[link];
78
79     [MethodImpl(MethodImplOptions.AggressiveInlining)]
80     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
81     {
82         ref var firstLink = ref LinksDataParts[first];
83         ref var secondLink = ref LinksDataParts[second];
84         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
85         ↪ secondLink.Source, secondLink.Target);
86     }
87
88     [MethodImpl(MethodImplOptions.AggressiveInlining)]
89     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
90     {
91         ref var firstLink = ref LinksDataParts[first];
92         ref var secondLink = ref LinksDataParts[second];
93         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
94         ↪ secondLink.Source, secondLink.Target);
95     }
96 }

```

1.50 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksSourcesSizeBalancedTreeMethods

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt64;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt64ExternalLinksSourcesSizeBalancedTreeMethods :
9      ↪ UInt64ExternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt64ExternalLinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink>
13         ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14         ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15         ↪ linksIndexParts, header) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref TLink GetLeftReference(TLink node) => ref
19         ↪ LinksIndexParts[node].LeftAsSource;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref TLink GetRightReference(TLink node) => ref
23         ↪ LinksIndexParts[node].RightAsSource;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsSource;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsSource;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33         ↪ LinksIndexParts[node].LeftAsSource = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37         ↪ LinksIndexParts[node].RightAsSource = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;

```

```

33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override void SetSize(TLink node, TLink size) =>
35     ↪ LinksIndexParts[node].SizeAsSource = size;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override TLink GetTreeRoot() => Header->RootAsSource;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
45     ↪ TLink secondSource, TLink secondTarget)
46     => firstSource < secondSource || firstSource == secondSource && firstTarget <
47     ↪ secondTarget;
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
51     ↪ TLink secondSource, TLink secondTarget)
52     => firstSource > secondSource || firstSource == secondSource && firstTarget >
53     ↪ secondTarget;
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override void ClearNode(TLink node)
57     {
58         ref var link = ref LinksIndexParts[node];
59         link.LeftAsSource = Zero;
60         link.RightAsSource = Zero;
61         link.SizeAsSource = Zero;
62     }
63 }

```

1.51 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksTargetsSizeBalancedTreeMethods

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt64;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt64ExternalLinksTargetsSizeBalancedTreeMethods :
9      ↪ UInt64ExternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt64ExternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink>
13         ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14         ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15         ↪ linksIndexParts, header) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref TLink GetLeftReference(TLink node) => ref
19         ↪ LinksIndexParts[node].LeftAsTarget;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref TLink GetRightReference(TLink node) => ref
23         ↪ LinksIndexParts[node].RightAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33         ↪ LinksIndexParts[node].LeftAsTarget = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37         ↪ LinksIndexParts[node].RightAsTarget = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override void SetSize(TLink node, TLink size) =>
44         ↪ LinksIndexParts[node].SizeAsTarget = size;
45     }
46 }

```



```

36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 protected override TLink GetTreeRoot() => Header->RootAsTarget;
38
39 [MethodImpl(MethodImplOptions.AggressiveInlining)]
40 protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
44     ↪ TLink secondSource, TLink secondTarget)
45     => firstTarget < secondTarget || firstTarget == secondTarget && firstSource <
46     ↪ secondSource;
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
50     ↪ TLink secondSource, TLink secondTarget)
51     => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
52     ↪ secondSource;
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 protected override void ClearNode(TLink node)
56 {
57     ref var link = ref LinksIndexParts[node];
58     link.LeftAsTarget = Zero;
59     link.RightAsTarget = Zero;
60     link.SizeAsTarget = Zero;
61 }
62 }

```

1.52 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSizeBalancedTreeMethodsBase.

```

1 using System.Runtime.CompilerServices;
2 using Platform.Data.Doublets.Memory.Split.Generic;
3 using TLink = System.UInt64;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Memory.Split.Specific
8 {
9     public unsafe abstract class UInt64InternalLinksSizeBalancedTreeMethodsBase :
10     ↪ InternalLinksSizeBalancedTreeMethodsBase<TLink>
11     {
12         protected new readonly RawLinkDataPart<TLink>* LinksDataParts;
13         protected new readonly RawLinkIndexPart<TLink>* LinksIndexParts;
14         protected new readonly LinksHeader<TLink>* Header;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected UInt64InternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink>
18     ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
19     ↪ linksIndexParts, LinksHeader<TLink>* header)
20             : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
21         {
22             LinksDataParts = linksDataParts;
23             LinksIndexParts = linksIndexParts;
24             Header = header;
25         }
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         protected override ulong GetZero() => OUL;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         protected override bool EqualToZero(ulong value) => value == OUL;
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         protected override bool AreEqual(ulong first, ulong second) => first == second;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override bool GreaterThanZero(ulong value) => value > OUL;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override bool GreaterThan(ulong first, ulong second) => first > second;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
47     ↪ always true for ulong
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

46     protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
    ↪ always >= 0 for ulong
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
    ↪ for ulong
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override bool LessThan(ulong first, ulong second) => first < second;
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override ulong Increment(ulong value) => ++value;
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override ulong Decrement(ulong value) => --value;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override ulong Add(ulong first, ulong second) => first + second;
65
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     protected override ulong Subtract(ulong first, ulong second) => first - second;
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
    ↪ ref LinksDataParts[link];
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
    ↪ ref LinksIndexParts[link];
74
75     [MethodImpl(MethodImplOptions.AggressiveInlining)]
76     protected override bool FirstIsToLeftOfSecond(TLink first, TLink second) =>
    ↪ GetKeyPartValue(first) < GetKeyPartValue(second);
77
78     [MethodImpl(MethodImplOptions.AggressiveInlining)]
79     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
    ↪ GetKeyPartValue(first) > GetKeyPartValue(second);
80 }
81 }

```

1.53 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSourcesSizeBalancedTreeMethod

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt64;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt64InternalLinksSourcesSizeBalancedTreeMethods :
    ↪ UInt64InternalLinksSizeBalancedTreeMethodsBase
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public UInt64InternalLinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink>
    ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
    ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
    ↪ linksIndexParts, header) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         protected override ref TLink GetLeftReference(TLink node) => ref
    ↪ LinksIndexParts[node].LeftAsSource;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected override ref TLink GetRightReference(TLink node) => ref
    ↪ LinksIndexParts[node].RightAsSource;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsSource;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsSource;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override void SetLeft(TLink node, TLink left) =>
    ↪ LinksIndexParts[node].LeftAsSource = left;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

29     protected override void SetRight(TLink node, TLink right) =>
        ↳ LinksIndexParts[node].RightAsSource = right;
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override void SetSize(TLink node, TLink size) =>
        ↳ LinksIndexParts[node].SizeAsSource = size;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsSource;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Target;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override void ClearNode(TLink node)
48     {
49         ref var link = ref LinksIndexParts[node];
50         link.LeftAsSource = Zero;
51         link.RightAsSource = Zero;
52         link.SizeAsSource = Zero;
53     }
54
55     public override TLink Search(TLink source, TLink target) =>
        ↳ SearchCore(GetTreeRoot(source), target);
56 }
57 }

```

1.54 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksTargetsSizeBalancedTreeMethod

```

1  using System.Runtime.CompilerServices;
2  using TLink = System.UInt64;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.Split.Specific
7  {
8      public unsafe class UInt64InternalLinksTargetsSizeBalancedTreeMethods :
9          ↳ UInt64InternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt64InternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink>
13             ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14             ↳ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15             ↳ linksIndexParts, header) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref ulong GetLeftReference(ulong node) => ref
19             ↳ LinksIndexParts[node].LeftAsTarget;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref ulong GetRightReference(ulong node) => ref
23             ↳ LinksIndexParts[node].RightAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetLeft(TLink node, TLink left) =>
33             ↳ LinksIndexParts[node].LeftAsTarget = left;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override void SetRight(TLink node, TLink right) =>
37             ↳ LinksIndexParts[node].RightAsTarget = right;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override void SetSize(TLink node, TLink size) =>
44             ↳ LinksIndexParts[node].SizeAsTarget = size;
45     }
46 }

```

```

37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsTarget;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Source;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override void ClearNode(TLink node)
48     {
49         ref var link = ref LinksIndexParts[node];
50         link.LeftAsTarget = Zero;
51         link.RightAsTarget = Zero;
52         link.SizeAsTarget = Zero;
53     }
54
55     public override TLink Search(TLink source, TLink target) =>
56         ↪ SearchCore(GetTreeRoot(target), source);
57 }

```

1.55 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64SplitMemoryLinks.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Singletons;
4  using Platform.Memory;
5  using Platform.Data.Doublets.Memory.Split.Generic;
6  using TLink = System.UInt64;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Memory.Split.Specific
11 {
12     public unsafe class UInt64SplitMemoryLinks : SplitMemoryLinksBase<TLink>
13     {
14         private readonly Func<ILinksTreeMethods<TLink>> _createInternalSourceTreeMethods;
15         private readonly Func<ILinksTreeMethods<TLink>> _createExternalSourceTreeMethods;
16         private readonly Func<ILinksTreeMethods<TLink>> _createInternalTargetTreeMethods;
17         private readonly Func<ILinksTreeMethods<TLink>> _createExternalTargetTreeMethods;
18         private LinksHeader<ulong>* _header;
19         private RawLinkDataPart<ulong>* _linksDataParts;
20         private RawLinkIndexPart<ulong>* _linksIndexParts;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public UInt64SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
24             ↪ indexMemory) : this(dataMemory, indexMemory, DefaultLinksSizeStep) { }
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public UInt64SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
28             ↪ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
29             ↪ memoryReservationStep, Default<LinksConstants<TLink>>.Instance) { }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public UInt64SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
33             ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants) :
34             ↪ base(dataMemory, indexMemory, memoryReservationStep, constants)
35         {
36             _createInternalSourceTreeMethods = () => new
37                 ↪ UInt64InternalLinksSourcesSizeBalancedTreeMethods(Constants, _linksDataParts,
38                 ↪ _linksIndexParts, _header);
39             _createExternalSourceTreeMethods = () => new
40                 ↪ UInt64ExternalLinksSourcesSizeBalancedTreeMethods(Constants, _linksDataParts,
41                 ↪ _linksIndexParts, _header);
42             _createInternalTargetTreeMethods = () => new
43                 ↪ UInt64InternalLinksTargetsSizeBalancedTreeMethods(Constants, _linksDataParts,
44                 ↪ _linksIndexParts, _header);
45             _createExternalTargetTreeMethods = () => new
46                 ↪ UInt64ExternalLinksTargetsSizeBalancedTreeMethods(Constants, _linksDataParts,
47                 ↪ _linksIndexParts, _header);
48             Init(dataMemory, indexMemory);
49         }
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override void SetPointers(IResizableDirectMemory dataMemory,
53             ↪ IResizableDirectMemory indexMemory)
54         {
55             _linksDataParts = (RawLinkDataPart<TLink>*)dataMemory.Pointer;
56         }
57     }
58 }

```

```

42     _linksIndexParts = (RawLinkIndexPart<TLink>*)indexMemory.Pointer;
43     _header = (LinksHeader<TLink>*)indexMemory.Pointer;
44     InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
45     ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
46     InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
47     ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
48     UnusedLinksListMethods = new UInt64UnusedLinksListMethods(_linksDataParts, _header);
49 }
50
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected override void ResetPointers()
53 {
54     base.ResetPointers();
55     _linksDataParts = null;
56     _linksIndexParts = null;
57     _header = null;
58 }
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
65     => ref _linksDataParts[linkIndex];
66
67 [MethodImpl(MethodImplOptions.AggressiveInlining)]
68 protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
69     linkIndex) => ref _linksIndexParts[linkIndex];
70
71 [MethodImpl(MethodImplOptions.AggressiveInlining)]
72 protected override bool AreEqual(ulong first, ulong second) => first == second;
73
74 [MethodImpl(MethodImplOptions.AggressiveInlining)]
75 protected override bool LessThan(ulong first, ulong second) => first < second;
76
77 [MethodImpl(MethodImplOptions.AggressiveInlining)]
78 protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 protected override bool GreaterThan(ulong first, ulong second) => first > second;
82
83 [MethodImpl(MethodImplOptions.AggressiveInlining)]
84 protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
85
86 [MethodImpl(MethodImplOptions.AggressiveInlining)]
87 protected override ulong GetZero() => 0UL;
88
89 [MethodImpl(MethodImplOptions.AggressiveInlining)]
90 protected override ulong GetOne() => 1UL;
91
92 [MethodImpl(MethodImplOptions.AggressiveInlining)]
93 protected override long ConvertToInt64(ulong value) => (long)value;
94
95 [MethodImpl(MethodImplOptions.AggressiveInlining)]
96 protected override ulong ConvertToAddress(long value) => (ulong)value;
97
98 [MethodImpl(MethodImplOptions.AggressiveInlining)]
99 protected override ulong Add(ulong first, ulong second) => first + second;
100
101 [MethodImpl(MethodImplOptions.AggressiveInlining)]
102 protected override ulong Subtract(ulong first, ulong second) => first - second;
103
104 [MethodImpl(MethodImplOptions.AggressiveInlining)]
105 protected override ulong Increment(ulong link) => ++link;
106
107 [MethodImpl(MethodImplOptions.AggressiveInlining)]
108 protected override ulong Decrement(ulong link) => --link;
109 }

```

1.56 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64UnusedLinksListMethods.cs

```

1 using System.Runtime.CompilerServices;
2 using Platform.Data.Doublets.Memory.Split.Generic;
3 using TLink = System.UInt64;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Memory.Split.Specific
8 {
9     public unsafe class UInt64UnusedLinksListMethods : UnusedLinksListMethods<TLink>

```

```

10 {
11     private readonly RawLinkDataPart<ulong>* _links;
12     private readonly LinksHeader<ulong>* _header;
13
14     [MethodImpl(MethodImplOptions.AggressiveInlining)]
15     public UInt64UnusedLinksListMethods(RawLinkDataPart<ulong>* links, LinksHeader<ulong>*
16         ↪ header)
17         : base((byte*)links, (byte*)header)
18     {
19         _links = links;
20         _header = header;
21     }
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
25         ↪ ref _links[link];
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
29 }

```

1.57 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksAvlBalancedTreeMethodsBase.cs

```

1 using System;
2 using System.Text;
3 using System.Collections.Generic;
4 using System.Runtime.CompilerServices;
5 using Platform.Collections.Methods.Trees;
6 using Platform.Converters;
7 using Platform.Numbers;
8 using static System.Runtime.CompilerServices.Unsafe;
9
10 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
11
12 namespace Platform.Data.Doublets.Memory.United.Generic
13 {
14     public unsafe abstract class LinksAvlBalancedTreeMethodsBase<TLink> :
15         ↪ SizedAndThreadedAVLBalancedTreeMethods<TLink>, ILinksTreeMethods<TLink>
16     {
17         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
18             ↪ UncheckedConverter<TLink, long>.Default;
19         private static readonly UncheckedConverter<TLink, int> _addressToInt32Converter =
20             ↪ UncheckedConverter<TLink, int>.Default;
21         private static readonly UncheckedConverter<bool, TLink> _boolToAddressConverter =
22             ↪ UncheckedConverter<bool, TLink>.Default;
23         private static readonly UncheckedConverter<TLink, bool> _addressToBoolConverter =
24             ↪ UncheckedConverter<TLink, bool>.Default;
25         private static readonly UncheckedConverter<int, TLink> _int32ToAddressConverter =
26             ↪ UncheckedConverter<int, TLink>.Default;
27
28         protected readonly TLink Break;
29         protected readonly TLink Continue;
30         protected readonly byte* Links;
31         protected readonly byte* Header;
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         protected LinksAvlBalancedTreeMethodsBase(LinksConstants<TLink> constants, byte* links,
35             ↪ byte* header)
36         {
37             Links = links;
38             Header = header;
39             Break = constants.Break;
40             Continue = constants.Continue;
41         }
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected abstract TLink GetTreeRoot();
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected abstract TLink GetBasePartValue(TLink link);
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
51             ↪ rootSource, TLink rootTarget);
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
55             ↪ rootSource, TLink rootTarget);
56
57         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

49     protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
    ↪ AsRef<LinksHeader<TLink>>(Header);

50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected virtual ref RawLink<TLink> GetLinkReference(TLink link) => ref
    ↪ AsRef<RawLink<TLink>>(Links + (RawLink<TLink>.SizeInBytes *
    ↪ _addressToInt64Converter.Convert(link)));

53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
56     {
57         ref var link = ref GetLinkReference(linkIndex);
58         return new Link<TLink>(linkIndex, link.Source, link.Target);
59     }

60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     protected override bool FirstIsToLeftOfSecond(TLink first, TLink second)
63     {
64         ref var firstLink = ref GetLinkReference(first);
65         ref var secondLink = ref GetLinkReference(second);
66         return FirstIsToLeftOfSecond(firstLink.Source, firstLink.Target,
    ↪ secondLink.Source, secondLink.Target);
67     }

68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
71     {
72         ref var firstLink = ref GetLinkReference(first);
73         ref var secondLink = ref GetLinkReference(second);
74         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
    ↪ secondLink.Source, secondLink.Target);
75     }

76
77     [MethodImpl(MethodImplOptions.AggressiveInlining)]
78     protected virtual TLink GetSizeValue(TLink value) => Bit<TLink>.PartialRead(value, 5,
    ↪ -5);

79
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     protected virtual void SetSizeValue(ref TLink storedValue, TLink size) => storedValue =
    ↪ Bit<TLink>.PartialWrite(storedValue, size, 5, -5);

82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected virtual bool GetLeftIsChildValue(TLink value)
85     {
86         unchecked
87         {
88             return _addressToBoolConverter.Convert(Bit<TLink>.PartialRead(value, 4, 1));
89             //return !EqualityComparer.Equals(Bit<TLink>.PartialRead(value, 4, 1), default);
90         }
91     }

92
93     [MethodImpl(MethodImplOptions.AggressiveInlining)]
94     protected virtual void SetLeftIsChildValue(ref TLink storedValue, bool value)
95     {
96         unchecked
97         {
98             var previousValue = storedValue;
99             var modified = Bit<TLink>.PartialWrite(previousValue,
    ↪ _boolToAddressConverter.Convert(value), 4, 1);
100             storedValue = modified;
101         }
102     }

103
104     [MethodImpl(MethodImplOptions.AggressiveInlining)]
105     protected virtual bool GetRightIsChildValue(TLink value)
106     {
107         unchecked
108         {
109             return _addressToBoolConverter.Convert(Bit<TLink>.PartialRead(value, 3, 1));
110             //return !EqualityComparer.Equals(Bit<TLink>.PartialRead(value, 3, 1), default);
111         }
112     }

113
114     [MethodImpl(MethodImplOptions.AggressiveInlining)]
115     protected virtual void SetRightIsChildValue(ref TLink storedValue, bool value)
116     {
117         unchecked
118         {

```

```

119     var previousValue = storedValue;
120     var modified = Bit<TLink>.PartialWrite(previousValue,
121     ↪     _boolToAddressConverter.Convert(value), 3, 1);
122     storedValue = modified;
123 }
124
125 [MethodImpl(MethodImplOptions.AggressiveInlining)]
126 protected bool IsChild(TLink parent, TLink possibleChild)
127 {
128     var parentSize = GetSize(parent);
129     var childSize = GetSizeOrZero(possibleChild);
130     return GreaterThanZero(childSize) && LessOrEqualThan(childSize, parentSize);
131 }
132
133 [MethodImpl(MethodImplOptions.AggressiveInlining)]
134 protected virtual sbyte GetBalanceValue(TLink storedValue)
135 {
136     unchecked
137     {
138         var value = _addressToInt32Converter.Convert(Bit<TLink>.PartialRead(storedValue,
139         ↪     0, 3));
140         value |= 0xF8 * ((value & 4) >> 2); // if negative, then continue ones to the
141         ↪     end of sbyte
142         return (sbyte)value;
143     }
144 }
145
146 [MethodImpl(MethodImplOptions.AggressiveInlining)]
147 protected virtual void SetBalanceValue(ref TLink storedValue, sbyte value)
148 {
149     unchecked
150     {
151         var packagedValue = _int32ToAddressConverter.Convert((byte)value >> 5 & 4 |
152         ↪     value & 3);
153         var modified = Bit<TLink>.PartialWrite(storedValue, packagedValue, 0, 3);
154         storedValue = modified;
155     }
156 }
157
158 public TLink this[TLink index]
159 {
160     [MethodImpl(MethodImplOptions.AggressiveInlining)]
161     get
162     {
163         var root = GetTreeRoot();
164         if (GreaterOrEqualThan(index, GetSize(root)))
165         {
166             return Zero;
167         }
168         while (!EqualToZero(root))
169         {
170             var left = GetLeftOrDefault(root);
171             var leftSize = GetSizeOrZero(left);
172             if (LessThan(index, leftSize))
173             {
174                 root = left;
175                 continue;
176             }
177             if (AreEqual(index, leftSize))
178             {
179                 return root;
180             }
181             root = GetRightOrDefault(root);
182             index = Subtract(index, Increment(leftSize));
183         }
184         return Zero; // TODO: Impossible situation exception (only if tree structure
185         ↪     broken)
186     }
187 }
188
189 /// <summary>
190 /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
191 ↪     (концом).
192 /// </summary>
193 /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
194 /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
195 /// <returns>Индекс искомой связи.</returns>

```



```

191 [MethodImpl(MethodImplOptions.AggressiveInlining)]
192 public TLink Search(TLink source, TLink target)
193 {
194     var root = GetTreeRoot();
195     while (!EqualToZero(root))
196     {
197         ref var rootLink = ref GetLinkReference(root);
198         var rootSource = rootLink.Source;
199         var rootTarget = rootLink.Target;
200         if (FirstIsToTheLeftOfSecond(source, target, rootSource, rootTarget)) //
201             ↪ node.Key < root.Key
202         {
203             root = GetLeftOrDefault(root);
204         }
205         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
206             ↪ node.Key > root.Key
207         {
208             root = GetRightOrDefault(root);
209         }
210         else // node.Key == root.Key
211         {
212             return root;
213         }
214     }
215     return Zero;
216 }
217
218 // TODO: Return indices range instead of references count
219 [MethodImpl(MethodImplOptions.AggressiveInlining)]
220 public TLink CountUsages(TLink link)
221 {
222     var root = GetTreeRoot();
223     var total = GetSize(root);
224     var totalRightIgnore = Zero;
225     while (!EqualToZero(root))
226     {
227         var @base = GetBasePartValue(root);
228         if (LessOrEqualThan(@base, link))
229         {
230             root = GetRightOrDefault(root);
231         }
232         else
233         {
234             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
235             root = GetLeftOrDefault(root);
236         }
237     }
238     root = GetTreeRoot();
239     var totalLeftIgnore = Zero;
240     while (!EqualToZero(root))
241     {
242         var @base = GetBasePartValue(root);
243         if (GreaterOrEqualThan(@base, link))
244         {
245             root = GetLeftOrDefault(root);
246         }
247         else
248         {
249             totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
250             root = GetRightOrDefault(root);
251         }
252     }
253     return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
254 }
255
256 [MethodImpl(MethodImplOptions.AggressiveInlining)]
257 public TLink EachUsage(TLink link, Func<IList<TLink>, TLink> handler)
258 {
259     var root = GetTreeRoot();
260     if (EqualToZero(root))
261     {
262         return Continue;
263     }
264     TLink first = Zero, current = root;
265     while (!EqualToZero(current))
266     {
267         var @base = GetBasePartValue(current);
268         if (GreaterOrEqualThan(@base, link))

```

```

268         {
269             if (AreEqual(@base, link))
270             {
271                 first = current;
272             }
273             current = GetLeftOrDefault(current);
274         }
275         else
276         {
277             current = GetRightOrDefault(current);
278         }
279     }
280     if (!EqualToZero(first))
281     {
282         current = first;
283         while (true)
284         {
285             if (AreEqual(handler(GetLinkValues(current)), Break))
286             {
287                 return Break;
288             }
289             current = GetNext(current);
290             if (EqualToZero(current) || !AreEqual(GetBasePartValue(current), link))
291             {
292                 break;
293             }
294         }
295     }
296     return Continue;
297 }
298
299 [MethodImpl(MethodImplOptions.AggressiveInlining)]
300 protected override void PrintNodeValue(TLink node, StringBuilder sb)
301 {
302     ref var link = ref GetLinkReference(node);
303     sb.Append(' ');
304     sb.Append(link.Source);
305     sb.Append('-');
306     sb.Append('>');
307     sb.Append(link.Target);
308 }
309 }
310 }

```

1.58 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksSizeBalancedTreeMethodsBase.cs

```

1  using System;
2  using System.Text;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Collections.Methods.Trees;
6  using Platform.Converters;
7  using static System.Runtime.CompilerServices.Unsafe;
8
9  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
10
11 namespace Platform.Data.Doublets.Memory.United.Generic
12 {
13     public unsafe abstract class LinksSizeBalancedTreeMethodsBase<TLink> :
14         ↳ SizeBalancedTreeMethods<TLink>, ILinksTreeMethods<TLink>
15     {
16         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
17             ↳ UncheckedConverter<TLink, long>.Default;
18
19         protected readonly TLink Break;
20         protected readonly TLink Continue;
21         protected readonly byte* Links;
22         protected readonly byte* Header;
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected LinksSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants, byte* links,
26             ↳ byte* header)
27         {
28             Links = links;
29             Header = header;
30             Break = constants.Break;
31             Continue = constants.Continue;
32         }
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected abstract TLink GetTreeRoot();

```

```

33 [MethodImpl(MethodImplOptions.AggressiveInlining)]
34 protected abstract TLink GetBasePartValue(TLink link);
35
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
38 ↪ rootSource, TLink rootTarget);
39
40 [MethodImpl(MethodImplOptions.AggressiveInlining)]
41 protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
42 ↪ rootSource, TLink rootTarget);
43
44 [MethodImpl(MethodImplOptions.AggressiveInlining)]
45 protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
46 ↪ AsRef<LinksHeader<TLink>>(Header);
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected virtual ref RawLink<TLink> GetLinkReference(TLink link) => ref
50 ↪ AsRef<RawLink<TLink>>(Links + (RawLink<TLink>.SizeInBytes *
51 ↪ _addressToInt64Converter.Convert(link)));
52
53 [MethodImpl(MethodImplOptions.AggressiveInlining)]
54 protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
55 {
56     ref var link = ref GetLinkReference(linkIndex);
57     return new Link<TLink>(linkIndex, link.Source, link.Target);
58 }
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
62 {
63     ref var firstLink = ref GetLinkReference(first);
64     ref var secondLink = ref GetLinkReference(second);
65     return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
66 ↪ secondLink.Source, secondLink.Target);
67 }
68
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
71 {
72     ref var firstLink = ref GetLinkReference(first);
73     ref var secondLink = ref GetLinkReference(second);
74     return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
75 ↪ secondLink.Source, secondLink.Target);
76 }
77
78 public TLink this[TLink index]
79 {
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     get
82     {
83         var root = GetTreeRoot();
84         if (GreaterOrEqualThan(index, GetSize(root)))
85         {
86             return Zero;
87         }
88         while (!EqualToZero(root))
89         {
90             var left = GetLeftOrDefault(root);
91             var leftSize = GetSizeOrZero(left);
92             if (LessThan(index, leftSize))
93             {
94                 root = left;
95                 continue;
96             }
97             if (AreEqual(index, leftSize))
98             {
99                 return root;
100             }
101             root = GetRightOrDefault(root);
102             index = Subtract(index, Increment(leftSize));
103         }
104         return Zero; // TODO: Impossible situation exception (only if tree structure
105 ↪ broken)
106     }
107 }
108
109 /// <summary>

```

```

103  /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
104  ↪ (концом).
105  /// </summary>
106  /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
107  /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
108  /// <returns>Индекс искомой связи.</returns>
109  [MethodImpl(MethodImplOptions.AggressiveInlining)]
110  public TLink Search(TLink source, TLink target)
111  {
112      var root = GetTreeRoot();
113      while (!EqualToZero(root))
114      {
115          ref var rootLink = ref GetLinkReference(root);
116          var rootSource = rootLink.Source;
117          var rootTarget = rootLink.Target;
118          if (FirstIsToTheLeftOfSecond(source, target, rootSource, rootTarget)) //
119              ↪ node.Key < root.Key
120          {
121              root = GetLeftOrDefault(root);
122          }
123          else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
124              ↪ node.Key > root.Key
125          {
126              root = GetRightOrDefault(root);
127          }
128          else // node.Key == root.Key
129          {
130              return root;
131          }
132      }
133      return Zero;
134  }
135
136  // TODO: Return indices range instead of references count
137  [MethodImpl(MethodImplOptions.AggressiveInlining)]
138  public TLink CountUsages(TLink link)
139  {
140      var root = GetTreeRoot();
141      var total = GetSize(root);
142      var totalRightIgnore = Zero;
143      while (!EqualToZero(root))
144      {
145          var @base = GetBasePartValue(root);
146          if (LessOrEqualThan(@base, link))
147          {
148              root = GetRightOrDefault(root);
149          }
150          else
151          {
152              totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
153              root = GetLeftOrDefault(root);
154          }
155      }
156      root = GetTreeRoot();
157      var totalLeftIgnore = Zero;
158      while (!EqualToZero(root))
159      {
160          var @base = GetBasePartValue(root);
161          if (GreaterOrEqualThan(@base, link))
162          {
163              root = GetLeftOrDefault(root);
164          }
165          else
166          {
167              totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
168              root = GetRightOrDefault(root);
169          }
170      }
171      return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
172  }
173
174  [MethodImpl(MethodImplOptions.AggressiveInlining)]
175  public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
176      ↪ EachUsageCore(@base, GetTreeRoot(), handler);
177
178  // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
179  ↪ low-level MSIL stack.
180  [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

176 private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
177 {
178     var @continue = Continue;
179     if (EqualToZero(link))
180     {
181         return @continue;
182     }
183     var linkBasePart = GetBasePartValue(link);
184     var @break = Break;
185     if (GreaterThan(linkBasePart, @base))
186     {
187         if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
188         {
189             return @break;
190         }
191     }
192     else if (LessThan(linkBasePart, @base))
193     {
194         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
195         {
196             return @break;
197         }
198     }
199     else //if (linkBasePart == @base)
200     {
201         if (AreEqual(handler(GetLinkValues(link)), @break))
202         {
203             return @break;
204         }
205         if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
206         {
207             return @break;
208         }
209         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
210         {
211             return @break;
212         }
213     }
214     return @continue;
215 }
216
217 [MethodImpl(MethodImplOptions.AggressiveInlining)]
218 protected override void PrintNodeValue(TLink node, StringBuilder sb)
219 {
220     ref var link = ref GetLinkReference(node);
221     sb.Append(' ');
222     sb.Append(link.Source);
223     sb.Append('-');
224     sb.Append('>');
225     sb.Append(link.Target);
226 }
227 }
228 }

```

1.59 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksSourcesAvlBalancedTreeMethods.cs

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Memory.United.Generic
6 {
7     public unsafe class LinksSourcesAvlBalancedTreeMethods<TLink> :
8         ↳ LinksAvlBalancedTreeMethodsBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksSourcesAvlBalancedTreeMethods(LinksConstants<TLink> constants, byte* links,
12             ↳ byte* header) : base(constants, links, header) { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref TLink GetLeftReference(TLink node) => ref
16             ↳ GetLinkReference(node).LeftAsSource;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref TLink GetRightReference(TLink node) => ref
20             ↳ GetLinkReference(node).RightAsSource;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsSource;
24
25     }
26 }

```

```

21 [MethodImpl(MethodImplOptions.AggressiveInlining)]
22 protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsSource;
23
24 [MethodImpl(MethodImplOptions.AggressiveInlining)]
25 protected override void SetLeft(TLink node, TLink left) =>
26     ↳ GetLinkReference(node).LeftAsSource = left;
27
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 protected override void SetRight(TLink node, TLink right) =>
30     ↳ GetLinkReference(node).RightAsSource = right;
31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 protected override TLink GetSize(TLink node) =>
34     ↳ GetSizeValue(GetLinkReference(node).SizeAsSource);
35
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 protected override void SetSize(TLink node, TLink size) => SetSizeValue(ref
38     ↳ GetLinkReference(node).SizeAsSource, size);
39
40 [MethodImpl(MethodImplOptions.AggressiveInlining)]
41 protected override bool GetLeftIsChild(TLink node) =>
42     ↳ GetLeftIsChildValue(GetLinkReference(node).SizeAsSource);
43
44 [MethodImpl(MethodImplOptions.AggressiveInlining)]
45 protected override void SetLeftIsChild(TLink node, bool value) =>
46     ↳ SetLeftIsChildValue(ref GetLinkReference(node).SizeAsSource, value);
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected override bool GetRightIsChild(TLink node) =>
50     ↳ GetRightIsChildValue(GetLinkReference(node).SizeAsSource);
51
52 [MethodImpl(MethodImplOptions.AggressiveInlining)]
53 protected override void SetRightIsChild(TLink node, bool value) =>
54     ↳ SetRightIsChildValue(ref GetLinkReference(node).SizeAsSource, value);
55
56 [MethodImpl(MethodImplOptions.AggressiveInlining)]
57 protected override sbyte GetBalance(TLink node) =>
58     ↳ GetBalanceValue(GetLinkReference(node).SizeAsSource);
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected override void SetBalance(TLink node, sbyte value) => SetBalanceValue(ref
62     ↳ GetLinkReference(node).SizeAsSource, value);
63
64 [MethodImpl(MethodImplOptions.AggressiveInlining)]
65 protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
66
67 [MethodImpl(MethodImplOptions.AggressiveInlining)]
68 protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Source;
69
70 [MethodImpl(MethodImplOptions.AggressiveInlining)]
71 protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
72     ↳ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
73     ↳ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
74
75 [MethodImpl(MethodImplOptions.AggressiveInlining)]
76 protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
77     ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
78     ↳ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 protected override void ClearNode(TLink node)
82 {
83     ref var link = ref GetLinkReference(node);
84     link.LeftAsSource = Zero;
85     link.RightAsSource = Zero;
86     link.SizeAsSource = Zero;
87 }
88 }
89 }

```

1.60 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksSourcesSizeBalancedTreeMethods.cs

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Memory.United.Generic
6 {
7     public unsafe class LinksSourcesSizeBalancedTreeMethods<TLink> :
8         ↳ LinksSizeBalancedTreeMethodsBase<TLink>

```

```

8 {
9     [MethodImpl(MethodImplOptions.AggressiveInlining)]
10    public LinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink> constants, byte* links,
11        ↪ byte* header) : base(constants, links, header) { }
12
13    [MethodImpl(MethodImplOptions.AggressiveInlining)]
14    protected override ref TLink GetLeftReference(TLink node) => ref
15        ↪ GetLinkReference(node).LeftAsSource;
16
17    [MethodImpl(MethodImplOptions.AggressiveInlining)]
18    protected override ref TLink GetRightReference(TLink node) => ref
19        ↪ GetLinkReference(node).RightAsSource;
20
21    [MethodImpl(MethodImplOptions.AggressiveInlining)]
22    protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsSource;
23
24    [MethodImpl(MethodImplOptions.AggressiveInlining)]
25    protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsSource;
26
27    [MethodImpl(MethodImplOptions.AggressiveInlining)]
28    protected override void SetLeft(TLink node, TLink left) =>
29        ↪ GetLinkReference(node).LeftAsSource = left;
30
31    [MethodImpl(MethodImplOptions.AggressiveInlining)]
32    protected override void SetRight(TLink node, TLink right) =>
33        ↪ GetLinkReference(node).RightAsSource = right;
34
35    [MethodImpl(MethodImplOptions.AggressiveInlining)]
36    protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsSource;
37
38    [MethodImpl(MethodImplOptions.AggressiveInlining)]
39    protected override void SetSize(TLink node, TLink size) =>
40        ↪ GetLinkReference(node).SizeAsSource = size;
41
42    [MethodImpl(MethodImplOptions.AggressiveInlining)]
43    protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
44
45    [MethodImpl(MethodImplOptions.AggressiveInlining)]
46    protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Source;
47
48    [MethodImpl(MethodImplOptions.AggressiveInlining)]
49    protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
50        ↪ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
51        ↪ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
52
53    [MethodImpl(MethodImplOptions.AggressiveInlining)]
54    protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
55        ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
56        ↪ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
57
58    [MethodImpl(MethodImplOptions.AggressiveInlining)]
59    protected override void ClearNode(TLink node)
60    {
61        ref var link = ref GetLinkReference(node);
62        link.LeftAsSource = Zero;
63        link.RightAsSource = Zero;
64        link.SizeAsSource = Zero;
65    }
66 }
67 }

```

1.61 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksTargetsAvlBalancedTreeMethods.cs

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Memory.United.Generic
6 {
7     public unsafe class LinksTargetsAvlBalancedTreeMethods<TLink> :
8         ↪ LinksAvlBalancedTreeMethodsBase<TLink>
9     {
10        [MethodImpl(MethodImplOptions.AggressiveInlining)]
11        public LinksTargetsAvlBalancedTreeMethods(LinksConstants<TLink> constants, byte* links,
12            ↪ byte* header) : base(constants, links, header) { }
13
14        [MethodImpl(MethodImplOptions.AggressiveInlining)]
15        protected override ref TLink GetLeftReference(TLink node) => ref
16            ↪ GetLinkReference(node).LeftAsTarget;
17
18    }
19 }

```

```

15 [MethodImpl(MethodImplOptions.AggressiveInlining)]
16 protected override ref TLink GetRightReference(TLink node) => ref
    ↳ GetLinkReference(node).RightAsTarget;
17
18 [MethodImpl(MethodImplOptions.AggressiveInlining)]
19 protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsTarget;
20
21 [MethodImpl(MethodImplOptions.AggressiveInlining)]
22 protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsTarget;
23
24 [MethodImpl(MethodImplOptions.AggressiveInlining)]
25 protected override void SetLeft(TLink node, TLink left) =>
    ↳ GetLinkReference(node).LeftAsTarget = left;
26
27 [MethodImpl(MethodImplOptions.AggressiveInlining)]
28 protected override void SetRight(TLink node, TLink right) =>
    ↳ GetLinkReference(node).RightAsTarget = right;
29
30 [MethodImpl(MethodImplOptions.AggressiveInlining)]
31 protected override TLink GetSize(TLink node) =>
    ↳ GetSizeValue(GetLinkReference(node).SizeAsTarget);
32
33 [MethodImpl(MethodImplOptions.AggressiveInlining)]
34 protected override void SetSize(TLink node, TLink size) => SetSizeValue(ref
    ↳ GetLinkReference(node).SizeAsTarget, size);
35
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 protected override bool GetLeftIsChild(TLink node) =>
    ↳ GetLeftIsChildValue(GetLinkReference(node).SizeAsTarget);
38
39 [MethodImpl(MethodImplOptions.AggressiveInlining)]
40 protected override void SetLeftIsChild(TLink node, bool value) =>
    ↳ SetLeftIsChildValue(ref GetLinkReference(node).SizeAsTarget, value);
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected override bool GetRightIsChild(TLink node) =>
    ↳ GetRightIsChildValue(GetLinkReference(node).SizeAsTarget);
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected override void SetRightIsChild(TLink node, bool value) =>
    ↳ SetRightIsChildValue(ref GetLinkReference(node).SizeAsTarget, value);
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected override sbyte GetBalance(TLink node) =>
    ↳ GetBalanceValue(GetLinkReference(node).SizeAsTarget);
50
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected override void SetBalance(TLink node, sbyte value) => SetBalanceValue(ref
    ↳ GetLinkReference(node).SizeAsTarget, value);
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 protected override TLink GetTreeRoot() => GetHeaderReference().RootAsTarget;
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Target;
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
    ↳ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
    ↳ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
    ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
    ↳ (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));
65
66 [MethodImpl(MethodImplOptions.AggressiveInlining)]
67 protected override void ClearNode(TLink node)
68 {
69     ref var link = ref GetLinkReference(node);
70     link.LeftAsTarget = Zero;
71     link.RightAsTarget = Zero;
72     link.SizeAsTarget = Zero;
73 }
74 }
75 }

```


1.62 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksTargetsSizeBalancedTreeMethods.cs

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Data.Doublets.Memory.United.Generic
6  {
7      public unsafe class LinksTargetsSizeBalancedTreeMethods<TLink> :
8          ↳ LinksSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink> constants, byte* links,
12             ↳ byte* header) : base(constants, links, header) { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref TLink GetLeftReference(TLink node) => ref
16             ↳ GetLinkReference(node).LeftAsTarget;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref TLink GetRightReference(TLink node) => ref
20             ↳ GetLinkReference(node).RightAsTarget;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsTarget;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override void SetLeft(TLink node, TLink left) =>
30             ↳ GetLinkReference(node).LeftAsTarget = left;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetRight(TLink node, TLink right) =>
34             ↳ GetLinkReference(node).RightAsTarget = right;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsTarget;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override void SetSize(TLink node, TLink size) =>
41             ↳ GetLinkReference(node).SizeAsTarget = size;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override TLink GetTreeRoot() => GetHeaderReference().RootAsTarget;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Target;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
51             ↳ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
52             ↳ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
56             ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
57             ↳ (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(TLink node)
61         {
62             ref var link = ref GetLinkReference(node);
63             link.LeftAsTarget = Zero;
64             link.RightAsTarget = Zero;
65             link.SizeAsTarget = Zero;
66         }
67     }
68 }

```

1.63 ./csharp/Platform.Data.Doublets/Memory/United/Generic/UnitedMemoryLinks.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Singletons;
4  using Platform.Memory;
5  using static System.Runtime.CompilerServices.Unsafe;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8

```

```

9 namespace Platform.Data.Doublets.Memory.United.Generic
10 {
11     public unsafe class UnitedMemoryLinks<TLink> : UnitedMemoryLinksBase<TLink>
12     {
13         private readonly Func<ILinksTreeMethods<TLink>> _createSourceTreeMethods;
14         private readonly Func<ILinksTreeMethods<TLink>> _createTargetTreeMethods;
15         private byte* _header;
16         private byte* _links;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public UnitedMemoryLinks(string address) : this(address, DefaultLinksSizeStep) { }
20
21         /// <summary>
22         /// Создаёт экземпляр базы данных Links в файле по указанному адресу, с указанным
23         /// → минимальным шагом расширения базы данных.
24         /// </summary>
25         /// <param name="address">Полный путь к файлу базы данных.</param>
26         /// <param name="memoryReservationStep">Минимальный шаг расширения базы данных в
27         /// → байтах.</param>
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public UnitedMemoryLinks(string address, long memoryReservationStep) : this(new
30         → FileMappedResizableDirectMemory(address, memoryReservationStep),
31         → memoryReservationStep) { }
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         public UnitedMemoryLinks(IResizableDirectMemory memory) : this(memory,
35         → DefaultLinksSizeStep) { }
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public UnitedMemoryLinks(IResizableDirectMemory memory, long memoryReservationStep) :
39         → this(memory, memoryReservationStep, Default<LinksConstants<TLink>>.Instance,
40         → IndexTreeType.Default) { }
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public UnitedMemoryLinks(IResizableDirectMemory memory, long memoryReservationStep,
44         → LinksConstants<TLink> constants, IndexTreeType indexTreeType) : base(memory,
45         → memoryReservationStep, constants)
46         {
47             if (indexTreeType == IndexTreeType.SizedAndThreadedAVLBalancedTree)
48             {
49                 _createSourceTreeMethods = () => new
50                 → LinksSourcesAvlBalancedTreeMethods<TLink>(Constants, _links, _header);
51                 _createTargetTreeMethods = () => new
52                 → LinksTargetsAvlBalancedTreeMethods<TLink>(Constants, _links, _header);
53             }
54             else
55             {
56                 _createSourceTreeMethods = () => new
57                 → LinksSourcesSizeBalancedTreeMethods<TLink>(Constants, _links, _header);
58                 _createTargetTreeMethods = () => new
59                 → LinksTargetsSizeBalancedTreeMethods<TLink>(Constants, _links, _header);
60             }
61             Init(memory, memoryReservationStep);
62         }
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         protected override void SetPointers(IResizableDirectMemory memory)
66         {
67             _links = (byte*)memory.Pointer;
68             _header = _links;
69             SourcesTreeMethods = _createSourceTreeMethods();
70             TargetsTreeMethods = _createTargetTreeMethods();
71             UnusedLinksListMethods = new UnusedLinksListMethods<TLink>(_links, _header);
72         }
73
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]
75         protected override void ResetPointers()
76         {
77             base.ResetPointers();
78             _links = null;
79             _header = null;
80         }
81
82         [MethodImpl(MethodImplOptions.AggressiveInlining)]
83         protected override ref LinksHeader<TLink> GetHeaderReference() => ref
84         → AsRef<LinksHeader<TLink>>(_header);
85
86         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

73         protected override ref RawLink<TLink> GetLinkReference(TLink linkIndex) => ref
74             ↳ AsRef<RawLink<TLink>>(_links + (LinkSizeInBytes * ConvertToInt64(linkIndex)));
75     }

```

1.64 ./csharp/Platform.Data.Doublets/Memory/United/Generic/UnitedMemoryLinksBase.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Disposables;
5  using Platform.Singletons;
6  using Platform.Converters;
7  using Platform.Numbers;
8  using Platform.Memory;
9  using Platform.Data.Exceptions;
10
11 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
12
13 namespace Platform.Data.Doublets.Memory.United.Generic
14 {
15     public abstract class UnitedMemoryLinksBase<TLink> : DisposableBase, ILinks<TLink>
16     {
17         private static readonly EqualityComparer<TLink> _equalityComparer =
18             ↳ EqualityComparer<TLink>.Default;
19         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
20         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
21             ↳ UncheckedConverter<TLink, long>.Default;
22         private static readonly UncheckedConverter<long, TLink> _int64ToAddressConverter =
23             ↳ UncheckedConverter<long, TLink>.Default;
24
25         private static readonly TLink _zero = default;
26         private static readonly TLink _one = Arithmetic.Increment(_zero);
27
28         /// <summary>Возвращает размер одной связи в байтах.</summary>
29         /// <remarks>
30         /// Используется только во вне класса, не рекомендуется использовать внутри.
31         /// Так как во вне не обязательно будет доступен unsafe C#.
32         /// </remarks>
33         public static readonly long LinkSizeInBytes = RawLink<TLink>.SizeInBytes;
34
35         public static readonly long LinkHeaderSizeInBytes = LinksHeader<TLink>.SizeInBytes;
36
37         public static readonly long DefaultLinksSizeStep = LinkSizeInBytes * 1024 * 1024;
38
39         protected readonly IResizableDirectMemory _memory;
40         protected readonly long _memoryReservationStep;
41
42         protected ILinksTreeMethods<TLink> TargetsTreeMethods;
43         protected ILinksTreeMethods<TLink> SourcesTreeMethods;
44         // TODO: Возможно чтобы гарантированно проверять на то, является ли связь удалённой,
45         ↳ нужно использовать не список а дерево, так как так можно быстрее проверить на
46         ↳ наличие связи внутри
47         protected ILinksListMethods<TLink> UnusedLinksListMethods;
48
49         /// <summary>
50         /// Возвращает общее число связей находящихся в хранилище.
51         /// </summary>
52         protected virtual TLink Total
53         {
54             [MethodImpl(MethodImplOptions.AggressiveInlining)]
55             get
56             {
57                 ref var header = ref GetHeaderReference();
58                 return Subtract(header.AllocatedLinks, header.FreeLinks);
59             }
60         }
61
62         public virtual LinksConstants<TLink> Constants
63         {
64             [MethodImpl(MethodImplOptions.AggressiveInlining)]
65             get;
66         }
67
68         [MethodImpl(MethodImplOptions.AggressiveInlining)]
69         protected UnitedMemoryLinksBase(IResizableDirectMemory memory, long
70             ↳ memoryReservationStep, LinksConstants<TLink> constants)
71         {
72             _memory = memory;
73             _memoryReservationStep = memoryReservationStep;
74             Constants = constants;
75         }

```

```

70 [MethodImpl(MethodImplOptions.AggressiveInlining)]
71 protected UnitedMemoryLinksBase(IResizableDirectMemory memory, long
72     ↪ memoryReservationStep) : this(memory, memoryReservationStep,
    ↪ Default<LinksConstants<TLink>>.Instance) { }

73
74 [MethodImpl(MethodImplOptions.AggressiveInlining)]
75 protected virtual void Init(IResizableDirectMemory memory, long memoryReservationStep)
76 {
77     if (memory.ReservedCapacity < memoryReservationStep)
78     {
79         memory.ReservedCapacity = memoryReservationStep;
80     }
81     SetPointers(memory);
82     ref var header = ref GetHeaderReference();
83     // Гарантия корректности _memory.UsedCapacity относительно _header->AllocatedLinks
84     memory.UsedCapacity = (ConvertToInt64(header.AllocatedLinks) * LinkSizeInBytes) +
    ↪ LinkHeaderSizeInBytes;
85     // Гарантия корректности _header->ReservedLinks относительно _memory.ReservedCapacity
86     header.ReservedLinks = ConvertToAddress((memory.ReservedCapacity -
    ↪ LinkHeaderSizeInBytes) / LinkSizeInBytes);
87 }
88
89 [MethodImpl(MethodImplOptions.AggressiveInlining)]
90 public virtual TLink Count(ICollection<TLink> restrictions)
91 {
92     // Если нет ограничений, тогда возвращаем общее число связей находящихся в хранилище.
93     if (restrictions.Count == 0)
94     {
95         return Total;
96     }
97     var constants = Constants;
98     var any = constants.Any;
99     var index = restrictions[constants.IndexPart];
100     if (restrictions.Count == 1)
101     {
102         if (AreEqual(index, any))
103         {
104             return Total;
105         }
106         return Exists(index) ? GetOne() : GetZero();
107     }
108     if (restrictions.Count == 2)
109     {
110         var value = restrictions[1];
111         if (AreEqual(index, any))
112         {
113             if (AreEqual(value, any))
114             {
115                 return Total; // Any - как отсутствие ограничения
116             }
117             return Add(SourcesTreeMethods.CountUsages(value),
    ↪ TargetsTreeMethods.CountUsages(value));
118         }
119         else
120         {
121             if (!Exists(index))
122             {
123                 return GetZero();
124             }
125             if (AreEqual(value, any))
126             {
127                 return GetOne();
128             }
129             ref var storedLinkValue = ref GetLinkReference(index);
130             if (AreEqual(storedLinkValue.Source, value) ||
    ↪ AreEqual(storedLinkValue.Target, value))
131             {
132                 return GetOne();
133             }
134             return GetZero();
135         }
136     }
137     if (restrictions.Count == 3)
138     {
139         var source = restrictions[constants.SourcePart];
140         var target = restrictions[constants.TargetPart];
141         if (AreEqual(index, any))

```

```

142 {
143     if (AreEqual(source, any) && AreEqual(target, any))
144     {
145         return Total;
146     }
147     else if (AreEqual(source, any))
148     {
149         return TargetsTreeMethods.CountUsages(target);
150     }
151     else if (AreEqual(target, any))
152     {
153         return SourcesTreeMethods.CountUsages(source);
154     }
155     else //if(source != Any && target != Any)
156     {
157         // Эквивалент Exists(source, target) => Count(Any, source, target) > 0
158         var link = SourcesTreeMethods.Search(source, target);
159         return AreEqual(link, constants.Null) ? GetZero() : GetOne();
160     }
161 }
162 else
163 {
164     if (!Exists(index))
165     {
166         return GetZero();
167     }
168     if (AreEqual(source, any) && AreEqual(target, any))
169     {
170         return GetOne();
171     }
172     ref var storedLinkValue = ref GetLinkReference(index);
173     if (!AreEqual(source, any) && !AreEqual(target, any))
174     {
175         if (AreEqual(storedLinkValue.Source, source) &&
176             ⇨ AreEqual(storedLinkValue.Target, target))
177         {
178             return GetOne();
179         }
180         return GetZero();
181     }
182     var value = default(TLink);
183     if (AreEqual(source, any))
184     {
185         value = target;
186     }
187     if (AreEqual(target, any))
188     {
189         value = source;
190     }
191     if (AreEqual(storedLinkValue.Source, value) ||
192         ⇨ AreEqual(storedLinkValue.Target, value))
193     {
194         return GetOne();
195     }
196     return GetZero();
197 }
198 }
199
200 [MethodImpl(MethodImplOptions.AggressiveInlining)]
201 public virtual TLink Each(Func<IList<TLink>, TLink> handler, IList<TLink> restrictions)
202 {
203     var constants = Constants;
204     var @break = constants.Break;
205     if (restrictions.Count == 0)
206     {
207         for (var link = GetOne(); LessOrEqualThan(link,
208             ⇨ GetHeaderReference().AllocatedLinks); link = Increment(link))
209         {
210             if (Exists(link) && AreEqual(handler(GetLinkStruct(link)), @break))
211             {
212                 return @break;
213             }
214         }
215     }
216     return @break;
217 }

```

```

216 var @continue = constants.Continue;
217 var any = constants.Any;
218 var index = restrictions[constants.IndexPart];
219 if (restrictions.Count == 1)
220 {
221     if (AreEqual(index, any))
222     {
223         return Each(handler, Array.Empty<TLink>());
224     }
225     if (!Exists(index))
226     {
227         return @continue;
228     }
229     return handler(GetLinkStruct(index));
230 }
231 if (restrictions.Count == 2)
232 {
233     var value = restrictions[1];
234     if (AreEqual(index, any))
235     {
236         if (AreEqual(value, any))
237         {
238             return Each(handler, Array.Empty<TLink>());
239         }
240         if (AreEqual(Each(handler, new Link<TLink>(index, value, any)), @break))
241         {
242             return @break;
243         }
244         return Each(handler, new Link<TLink>(index, any, value));
245     }
246     else
247     {
248         if (!Exists(index))
249         {
250             return @continue;
251         }
252         if (AreEqual(value, any))
253         {
254             return handler(GetLinkStruct(index));
255         }
256         ref var storedLinkValue = ref GetLinkReference(index);
257         if (AreEqual(storedLinkValue.Source, value) ||
258             AreEqual(storedLinkValue.Target, value))
259         {
260             return handler(GetLinkStruct(index));
261         }
262         return @continue;
263     }
264 }
265 if (restrictions.Count == 3)
266 {
267     var source = restrictions[constants.SourcePart];
268     var target = restrictions[constants.TargetPart];
269     if (AreEqual(index, any))
270     {
271         if (AreEqual(source, any) && AreEqual(target, any))
272         {
273             return Each(handler, Array.Empty<TLink>());
274         }
275         else if (AreEqual(source, any))
276         {
277             return TargetsTreeMethods.EachUsage(target, handler);
278         }
279         else if (AreEqual(target, any))
280         {
281             return SourcesTreeMethods.EachUsage(source, handler);
282         }
283         else //if(source != Any && target != Any)
284         {
285             var link = SourcesTreeMethods.Search(source, target);
286             return AreEqual(link, constants.Null) ? @continue :
287                 ↪ handler(GetLinkStruct(link));
288         }
289     }
290     else
291     {
292         if (!Exists(index))
293         {

```

```

293         return @continue;
294     }
295     if (AreEqual(source, any) && AreEqual(target, any))
296     {
297         return handler(GetLinkStruct(index));
298     }
299     ref var storedLinkValue = ref GetLinkReference(index);
300     if (!AreEqual(source, any) && !AreEqual(target, any))
301     {
302         if (AreEqual(storedLinkValue.Source, source) &&
303             AreEqual(storedLinkValue.Target, target))
304         {
305             return handler(GetLinkStruct(index));
306         }
307         return @continue;
308     }
309     var value = default(TLink);
310     if (AreEqual(source, any))
311     {
312         value = target;
313     }
314     if (AreEqual(target, any))
315     {
316         value = source;
317     }
318     if (AreEqual(storedLinkValue.Source, value) ||
319         AreEqual(storedLinkValue.Target, value))
320     {
321         return handler(GetLinkStruct(index));
322     }
323     return @continue;
324 }
325 }
326 throw new NotSupportedException("Другие размеры и способы ограничений не
    ↳ поддерживаются.");
327 }
328
329 /// <remarks>
330 /// TODO: Возможно можно перемещать значения, если указан индекс, но значение существует
331 ↳ в другом месте (но не в менеджере памяти, а в логике Links)
332 /// </remarks>
333 [MethodImpl(MethodImplOptions.AggressiveInlining)]
334 public virtual TLink Update(ICollection<TLink> restrictions, ICollection<TLink> substitution)
335 {
336     var constants = Constants;
337     var @null = constants.Null;
338     var linkIndex = restrictions[constants.IndexPart];
339     ref var link = ref GetLinkReference(linkIndex);
340     ref var header = ref GetHeaderReference();
341     ref var firstAsSource = ref header.RootAsSource;
342     ref var firstAsTarget = ref header.RootAsTarget;
343     // Будет корректно работать только в том случае, если пространство выделенной связи
344     ↳ предварительно заполнено нулями
345     if (!AreEqual(link.Source, @null))
346     {
347         SourcesTreeMethods.Detach(ref firstAsSource, linkIndex);
348     }
349     if (!AreEqual(link.Target, @null))
350     {
351         TargetsTreeMethods.Detach(ref firstAsTarget, linkIndex);
352     }
353     link.Source = substitution[constants.SourcePart];
354     link.Target = substitution[constants.TargetPart];
355     if (!AreEqual(link.Source, @null))
356     {
357         SourcesTreeMethods.Attach(ref firstAsSource, linkIndex);
358     }
359     if (!AreEqual(link.Target, @null))
360     {
361         TargetsTreeMethods.Attach(ref firstAsTarget, linkIndex);
362     }
363     return linkIndex;
364 }
365
366 /// <remarks>
367 /// TODO: Возможно нужно будет заполнение нулями, если внешнее API ими не заполняет
368 ↳ пространство
369 /// </remarks>

```

```

367 [MethodImpl(MethodImplOptions.AggressiveInlining)]
368 public virtual TLink Create(ICollection<TLink> restrictions)
369 {
370     ref var header = ref GetHeaderReference();
371     var freeLink = header.FirstFreeLink;
372     if (!AreEqual(freeLink, Constants.Null))
373     {
374         UnusedLinksListMethods.Detach(freeLink);
375     }
376     else
377     {
378         var maximumPossibleInnerReference = Constants.InternalReferencesRange.Maximum;
379         if (GreaterThan(header.AllocatedLinks, maximumPossibleInnerReference))
380         {
381             throw new LinksLimitReachedException<TLink>(maximumPossibleInnerReference);
382         }
383         if (GreaterOrEqualThan(header.AllocatedLinks, Decrement(header.ReservedLinks)))
384         {
385             _memory.ReservedCapacity += _memory.ReservationStep;
386             SetPointers(_memory);
387             header = ref GetHeaderReference();
388             header.ReservedLinks = ConvertToAddress(_memory.ReservedCapacity /
389                 ↳ LinkSizeInBytes);
390             header.AllocatedLinks = Increment(header.AllocatedLinks);
391             _memory.UsedCapacity += LinkSizeInBytes;
392             freeLink = header.AllocatedLinks;
393         }
394         return freeLink;
395     }
396
397 [MethodImpl(MethodImplOptions.AggressiveInlining)]
398 public virtual void Delete(ICollection<TLink> restrictions)
399 {
400     ref var header = ref GetHeaderReference();
401     var link = restrictions[Constants.IndexPart];
402     if (LessThan(link, header.AllocatedLinks)
403     {
404         UnusedLinksListMethods.AttachAsFirst(link);
405     }
406     else if (AreEqual(link, header.AllocatedLinks))
407     {
408         header.AllocatedLinks = Decrement(header.AllocatedLinks);
409         _memory.UsedCapacity -= LinkSizeInBytes;
410         // Убираем все связи, находящиеся в списке свободных в конце файла, до тех пор,
411         ↳ пока не дойдём до первой существующей связи
412         // Позволяет оптимизировать количество выделенных связей (AllocatedLinks)
413         while (GreaterThan(header.AllocatedLinks, GetZero()) &&
414             ↳ IsUnusedLink(header.AllocatedLinks))
415         {
416             UnusedLinksListMethods.Detach(header.AllocatedLinks);
417             header.AllocatedLinks = Decrement(header.AllocatedLinks);
418             _memory.UsedCapacity -= LinkSizeInBytes;
419         }
420     }
421
422 [MethodImpl(MethodImplOptions.AggressiveInlining)]
423 public IList<TLink> GetLinkStruct(TLink linkIndex)
424 {
425     ref var link = ref GetLinkReference(linkIndex);
426     return new Link<TLink>(linkIndex, link.Source, link.Target);
427 }
428
429 /// <remarks>
430 /// TODO: Возможно это должно быть событием, вызываемым из IMemory, в том случае, если
431 ↳ адрес реально поменялся
432 ///
433 /// Указатель this.links может быть в том же месте,
434 /// так как 0-я связь не используется и имеет такой же размер как Header,
435 /// поэтому header размещается в том же месте, что и 0-я связь
436 /// </remarks>
437 [MethodImpl(MethodImplOptions.AggressiveInlining)]
438 protected abstract void SetPointers(IResizableDirectMemory memory);
439
440 [MethodImpl(MethodImplOptions.AggressiveInlining)]
441 protected virtual void ResetPointers()
442 {
443     SourcesTreeMethods = null;

```



```

442     TargetsTreeMethods = null;
443     UnusedLinksListMethods = null;
444 }
445
446 [MethodImpl(MethodImplOptions.AggressiveInlining)]
447 protected abstract ref LinksHeader<TLink> GetHeaderReference();
448
449 [MethodImpl(MethodImplOptions.AggressiveInlining)]
450 protected abstract ref RawLink<TLink> GetLinkReference(TLink linkIndex);
451
452 [MethodImpl(MethodImplOptions.AggressiveInlining)]
453 protected virtual bool Exists(TLink link)
454     => GreaterOrEqualThan(link, Constants.InternalReferencesRange.Minimum)
455     && LessOrEqualThan(link, GetHeaderReference().AllocatedLinks)
456     && !IsUnusedLink(link);
457
458 [MethodImpl(MethodImplOptions.AggressiveInlining)]
459 protected virtual bool IsUnusedLink(TLink linkIndex)
460 {
461     if (!AreEqual(GetHeaderReference().FirstFreeLink, linkIndex)) // May be this check
462         ↪ is not needed
463     {
464         ref var link = ref GetLinkReference(linkIndex);
465         return AreEqual(link.SizeAsSource, default) && !AreEqual(link.Source, default);
466     }
467     else
468     {
469         return true;
470     }
471 }
472
473 [MethodImpl(MethodImplOptions.AggressiveInlining)]
474 protected virtual TLink GetOne() => _one;
475
476 [MethodImpl(MethodImplOptions.AggressiveInlining)]
477 protected virtual TLink GetZero() => default;
478
479 [MethodImpl(MethodImplOptions.AggressiveInlining)]
480 protected virtual bool AreEqual(TLink first, TLink second) =>
481     ↪ _equalityComparer.Equals(first, second);
482
483 [MethodImpl(MethodImplOptions.AggressiveInlining)]
484 protected virtual bool LessThan(TLink first, TLink second) => _comparer.Compare(first,
485     ↪ second) < 0;
486
487 [MethodImpl(MethodImplOptions.AggressiveInlining)]
488 protected virtual bool LessOrEqualThan(TLink first, TLink second) =>
489     ↪ _comparer.Compare(first, second) <= 0;
490
491 [MethodImpl(MethodImplOptions.AggressiveInlining)]
492 protected virtual bool GreaterThan(TLink first, TLink second) =>
493     ↪ _comparer.Compare(first, second) > 0;
494
495 [MethodImpl(MethodImplOptions.AggressiveInlining)]
496 protected virtual bool GreaterOrEqualThan(TLink first, TLink second) =>
497     ↪ _comparer.Compare(first, second) >= 0;
498
499 [MethodImpl(MethodImplOptions.AggressiveInlining)]
500 protected virtual long ConvertToInt64(TLink value) =>
501     ↪ _addressToInt64Converter.Convert(value);
502
503 [MethodImpl(MethodImplOptions.AggressiveInlining)]
504 protected virtual TLink ConvertToAddress(long value) =>
505     ↪ _int64ToAddressConverter.Convert(value);
506
507 [MethodImpl(MethodImplOptions.AggressiveInlining)]
508 protected virtual TLink Add(TLink first, TLink second) => Arithmetic<TLink>.Add(first,
509     ↪ second);
510
511 [MethodImpl(MethodImplOptions.AggressiveInlining)]
512 protected virtual TLink Subtract(TLink first, TLink second) =>
513     ↪ Arithmetic<TLink>.Subtract(first, second);
514
515 [MethodImpl(MethodImplOptions.AggressiveInlining)]
516 protected virtual TLink Increment(TLink link) => Arithmetic<TLink>.Increment(link);
517
518 [MethodImpl(MethodImplOptions.AggressiveInlining)]
519 protected virtual TLink Decrement(TLink link) => Arithmetic<TLink>.Decrement(link);

```

```

511     #region Disposable
512
513     protected override bool AllowMultipleDisposeCalls
514     {
515         [MethodImpl(MethodImplOptions.AggressiveInlining)]
516         get => true;
517     }
518
519     [MethodImpl(MethodImplOptions.AggressiveInlining)]
520     protected override void Dispose(bool manual, bool wasDisposed)
521     {
522         if (!wasDisposed)
523         {
524             ResetPointers();
525             _memory.DisposeIfPossible();
526         }
527     }
528
529     #endregion
530 }
531 }

```

1.65 ./csharp/Platform.Data.Doublets/Memory/United/Generic/UnusedLinksListMethods.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Collections.Methods.Lists;
3  using Platform.Converters;
4  using static System.Runtime.CompilerServices.Unsafe;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Memory.United.Generic
9  {
10     public unsafe class UnusedLinksListMethods<TLink> : CircularDoublyLinkedListMethods<TLink>,
11         ↳ ILinksListMethods<TLink>
12     {
13         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
14             ↳ UncheckedConverter<TLink, long>.Default;
15
16         private readonly byte* _links;
17         private readonly byte* _header;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public UnusedLinksListMethods(byte* links, byte* header)
21         {
22             _links = links;
23             _header = header;
24         }
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
28             ↳ AsRef<LinksHeader<TLink>>(_header);
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         protected virtual ref RawLink<TLink> GetLinkReference(TLink link) => ref
32             ↳ AsRef<RawLink<TLink>>(_links + (RawLink<TLink>.SizeInBytes *
33             ↳ _addressToInt64Converter.Convert(link)));
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override TLink GetFirst() => GetHeaderReference().FirstFreeLink;
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         protected override TLink GetLast() => GetHeaderReference().LastFreeLink;
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         protected override TLink GetPrevious(TLink element) => GetLinkReference(element).Source;
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         protected override TLink GetNext(TLink element) => GetLinkReference(element).Target;
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override TLink GetSize() => GetHeaderReference().FreeLinks;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override void SetFirst(TLink element) => GetHeaderReference().FirstFreeLink =
52             ↳ element;
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected override void SetLast(TLink element) => GetHeaderReference().LastFreeLink =
56             ↳ element;
57     }
58 }

```

```

51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override void SetPrevious(TLink element, TLink previous) =>
        ↳ GetLinkReference(element).Source = previous;
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override void SetNext(TLink element, TLink next) =>
        ↳ GetLinkReference(element).Target = next;
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override void SetSize(TLink size) => GetHeaderReference().FreeLinks = size;
59 }
60 }

```

1.66 ./csharp/Platform.Data.Doublets/Memory/United/RawLink.cs

```

1  using Platform.Unsafe;
2  using System;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Memory.United
9  {
10     public struct RawLink<TLink> : IEquatable<RawLink<TLink>>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
            ↳ EqualityComparer<TLink>.Default;
13
14         public static readonly long SizeInBytes = Structure<RawLink<TLink>>.Size;
15
16         public TLink Source;
17         public TLink Target;
18         public TLink LeftAsSource;
19         public TLink RightAsSource;
20         public TLink SizeAsSource;
21         public TLink LeftAsTarget;
22         public TLink RightAsTarget;
23         public TLink SizeAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public override bool Equals(object obj) => obj is RawLink<TLink> link ? Equals(link) :
            ↳ false;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public bool Equals(RawLink<TLink> other)
30             => _equalityComparer.Equals(Source, other.Source)
31                 && _equalityComparer.Equals(Target, other.Target)
32                 && _equalityComparer.Equals(LeftAsSource, other.LeftAsSource)
33                 && _equalityComparer.Equals(RightAsSource, other.RightAsSource)
34                 && _equalityComparer.Equals(SizeAsSource, other.SizeAsSource)
35                 && _equalityComparer.Equals(LeftAsTarget, other.LeftAsTarget)
36                 && _equalityComparer.Equals(RightAsTarget, other.RightAsTarget)
37                 && _equalityComparer.Equals(SizeAsTarget, other.SizeAsTarget);
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         public override int GetHashCode() => (Source, Target, LeftAsSource, RightAsSource,
            ↳ SizeAsSource, LeftAsTarget, RightAsTarget, SizeAsTarget).GetHashCode();
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public static bool operator ==(RawLink<TLink> left, RawLink<TLink> right) =>
            ↳ left.Equals(right);
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public static bool operator !=(RawLink<TLink> left, RawLink<TLink> right) => !(left ==
            ↳ right);
47     }
48 }

```

1.67 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksSizeBalancedTreeMethodsBase.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Data.Doublets.Memory.United.Generic;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.United.Specific
7  {
8     public unsafe abstract class UInt32LinksSizeBalancedTreeMethodsBase :
        ↳ LinksSizeBalancedTreeMethodsBase<uint>
9     {
10         protected new readonly RawLink<uint>* Links;

```

```

11     protected new readonly LinksHeader<uint>* Header;
12
13     protected UInt32LinksSizeBalancedTreeMethodsBase(LinksConstants<uint> constants,
14     ↪ RawLink<uint>* links, LinksHeader<uint>* header)
15         : base(constants, (byte*)links, (byte*)header)
16     {
17         Links = links;
18         Header = header;
19     }
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override uint GetZero() => 0U;
23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override bool EqualToZero(uint value) => value == 0U;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override bool AreEqual(uint first, uint second) => first == second;
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     protected override bool GreaterThanZero(uint value) => value > 0U;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override bool GreaterThan(uint first, uint second) => first > second;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override bool GreaterOrEqualThan(uint first, uint second) => first >= second;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override bool GreaterOrEqualThanZero(uint value) => true; // value >= 0 is
41     ↪ always true for uint
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override bool LessOrEqualThanZero(uint value) => value == 0U; // value is
45     ↪ always >= 0 for uint
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override bool LessOrEqualThan(uint first, uint second) => first <= second;
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool LessThanZero(uint value) => false; // value < 0 is always false
52     ↪ for uint
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override bool LessThan(uint first, uint second) => first < second;
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override uint Increment(uint value) => ++value;
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override uint Decrement(uint value) => --value;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override uint Add(uint first, uint second) => first + second;
65
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     protected override uint Subtract(uint first, uint second) => first - second;
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override bool FirstIsToTheLeftOfSecond(uint first, uint second)
71     {
72         ref var firstLink = ref Links[first];
73         ref var secondLink = ref Links[second];
74         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
75         ↪ secondLink.Source, secondLink.Target);
76     }
77
78     [MethodImpl(MethodImplOptions.AggressiveInlining)]
79     protected override bool FirstIsToTheRightOfSecond(uint first, uint second)
80     {
81         ref var firstLink = ref Links[first];
82         ref var secondLink = ref Links[second];
83         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
84         ↪ secondLink.Source, secondLink.Target);
85     }
86
87     [MethodImpl(MethodImplOptions.AggressiveInlining)]
88     protected override ref LinksHeader<uint> GetHeaderReference() => ref *Header;
89

```

```

84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     protected override ref RawLink<uint> GetLinkReference(uint link) => ref Links[link];
86 }
87 }

```

1.68 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksSourcesSizeBalancedTreeMethods.cs

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Data.Doublets.Memory.United.Specific
6  {
7      public unsafe class UInt32LinksSourcesSizeBalancedTreeMethods :
8          ↳ UInt32LinksSizeBalancedTreeMethodsBase
9      {
10
11         public UInt32LinksSourcesSizeBalancedTreeMethods(LinksConstants<uint> constants,
12             ↳ RawLink<uint>* links, LinksHeader<uint>* header) : base(constants, links, header) { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref uint GetLeftReference(uint node) => ref Links[node].LeftAsSource;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ref uint GetRightReference(uint node) => ref
19             ↳ Links[node].RightAsSource;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override uint GetLeft(uint node) => Links[node].LeftAsSource;
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected override uint GetRight(uint node) => Links[node].RightAsSource;
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         protected override void SetLeft(uint node, uint left) => Links[node].LeftAsSource = left;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         protected override void SetRight(uint node, uint right) => Links[node].RightAsSource =
32             ↳ right;
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected override uint GetSize(uint node) => Links[node].SizeAsSource;
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected override void SetSize(uint node, uint size) => Links[node].SizeAsSource = size;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override uint GetTreeRoot() => Header->RootAsSource;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override uint GetBasePartValue(uint link) => Links[link].Source;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override bool FirstIsToTheLeftOfSecond(uint firstSource, uint firstTarget,
48             ↳ uint secondSource, uint secondTarget)
49             => firstSource < secondSource || (firstSource == secondSource && firstTarget <
50                 ↳ secondTarget);
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]
53         protected override bool FirstIsToTheRightOfSecond(uint firstSource, uint firstTarget,
54             ↳ uint secondSource, uint secondTarget)
55             => firstSource > secondSource || (firstSource == secondSource && firstTarget >
56                 ↳ secondTarget);
57
58         [MethodImpl(MethodImplOptions.AggressiveInlining)]
59         protected override void ClearNode(uint node)
60         {
61             ref var link = ref Links[node];
62             link.LeftAsSource = 0U;
63             link.RightAsSource = 0U;
64             link.SizeAsSource = 0U;
65         }
66     }
67 }

```

1.69 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksTargetsSizeBalancedTreeMethods.cs

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Data.Doublets.Memory.United.Specific

```

```

6 {
7     public unsafe class UInt32LinksTargetsSizeBalancedTreeMethods :
8         ↳ UInt32LinksSizeBalancedTreeMethodsBase
9     {
10         public UInt32LinksTargetsSizeBalancedTreeMethods(LinksConstants<uint> constants,
11             ↳ RawLink<uint>* links, LinksHeader<uint>* header) : base(constants, links, header) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         protected override ref uint GetLeftReference(uint node) => ref Links[node].LeftAsTarget;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected override ref uint GetRightReference(uint node) => ref
18             ↳ Links[node].RightAsTarget;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override uint GetLeft(uint node) => Links[node].LeftAsTarget;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override uint GetRight(uint node) => Links[node].RightAsTarget;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override void SetLeft(uint node, uint left) => Links[node].LeftAsTarget = left;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override void SetRight(uint node, uint right) => Links[node].RightAsTarget =
31             ↳ right;
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         protected override uint GetSize(uint node) => Links[node].SizeAsTarget;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override void SetSize(uint node, uint size) => Links[node].SizeAsTarget = size;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override uint GetTreeRoot() => Header->RootAsTarget;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override uint GetBasePartValue(uint link) => Links[link].Target;
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected override bool FirstIsToTheLeftOfSecond(uint firstSource, uint firstTarget,
47             ↳ uint secondSource, uint secondTarget)
48             => firstTarget < secondTarget || (firstTarget == secondTarget && firstSource <
49                 ↳ secondSource);
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override bool FirstIsToTheRightOfSecond(uint firstSource, uint firstTarget,
53             ↳ uint secondSource, uint secondTarget)
54             => firstTarget > secondTarget || (firstTarget == secondTarget && firstSource >
55                 ↳ secondSource);
56
57         [MethodImpl(MethodImplOptions.AggressiveInlining)]
58         protected override void ClearNode(uint node)
59         {
60             ref var link = ref Links[node];
61             link.LeftAsTarget = 0U;
62             link.RightAsTarget = 0U;
63             link.SizeAsTarget = 0U;
64         }
65     }
66 }

```

1.70 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32UnitedMemoryLinks.cs

```

1 using System;
2 using System.Runtime.CompilerServices;
3 using Platform.Memory;
4 using Platform.Singletons;
5 using Platform.Data.Doublets.Memory.United.Generic;
6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublets.Memory.United.Specific
10 {
11     /// <summary>
12     /// <para>Represents a low-level implementation of direct access to resizable memory, for
13     ↳ organizing the storage of links with addresses represented as <see cref="uint" />.</para>
14     /// <para>Представляет низкоуровневую реализация прямого доступа к памяти с переменным
15     ↳ размером, для организации хранения связей с адресами представленными в виде <see
16     ↳ cref="uint" />.</para>

```

```

14  /// </summary>
15  public unsafe class UInt32UnitedMemoryLinks : UnitedMemoryLinksBase<uint>
16  {
17      private readonly Func<ILinksTreeMethods<uint>> _createSourceTreeMethods;
18      private readonly Func<ILinksTreeMethods<uint>> _createTargetTreeMethods;
19      private LinksHeader<uint>* _header;
20      private RawLink<uint>* _links;
21
22      [MethodImpl(MethodImplOptions.AggressiveInlining)]
23      public UInt32UnitedMemoryLinks(string address) : this(address, DefaultLinksSizeStep) { }
24
25      /// <summary>
26      /// Создаёт экземпляр базы данных Links в файле по указанному адресу, с указанным
27      /// → минимальным шагом расширения базы данных.
28      /// </summary>
29      /// <param name="address">Полный путь к файлу базы данных.</param>
30      /// <param name="memoryReservationStep">Минимальный шаг расширения базы данных в
31      /// → байтах.</param>
32      [MethodImpl(MethodImplOptions.AggressiveInlining)]
33      public UInt32UnitedMemoryLinks(string address, long memoryReservationStep) : this(new
34      → FileMappedResizableDirectMemory(address, memoryReservationStep),
35      → memoryReservationStep) { }
36
37      [MethodImpl(MethodImplOptions.AggressiveInlining)]
38      public UInt32UnitedMemoryLinks(IResizableDirectMemory memory) : this(memory,
39      → DefaultLinksSizeStep) { }
40
41      [MethodImpl(MethodImplOptions.AggressiveInlining)]
42      public UInt32UnitedMemoryLinks(IResizableDirectMemory memory, long
43      → memoryReservationStep) : this(memory, memoryReservationStep,
44      → Default<LinksConstants<uint>>.Instance, IndexTreeType.Default) { }
45
46      [MethodImpl(MethodImplOptions.AggressiveInlining)]
47      public UInt32UnitedMemoryLinks(IResizableDirectMemory memory, long
48      → memoryReservationStep, LinksConstants<uint> constants, IndexTreeType indexTreeType)
49      → : base(memory, memoryReservationStep, constants)
50      {
51          _createSourceTreeMethods = () => new
52          → UInt32LinksSourcesSizeBalancedTreeMethods(Constants, _links, _header);
53          _createTargetTreeMethods = () => new
54          → UInt32LinksTargetsSizeBalancedTreeMethods(Constants, _links, _header);
55          Init(memory, memoryReservationStep);
56      }
57
58      [MethodImpl(MethodImplOptions.AggressiveInlining)]
59      protected override void SetPointers(IResizableDirectMemory memory)
60      {
61          _header = (LinksHeader<uint>*)memory.Pointer;
62          _links = (RawLink<uint>*)memory.Pointer;
63          SourcesTreeMethods = _createSourceTreeMethods();
64          TargetsTreeMethods = _createTargetTreeMethods();
65          UnusedLinksListMethods = new UInt32UnusedLinksListMethods(_links, _header);
66      }
67
68      [MethodImpl(MethodImplOptions.AggressiveInlining)]
69      protected override void ResetPointers()
70      {
71          base.ResetPointers();
72          _links = null;
73          _header = null;
74      }
75
76      [MethodImpl(MethodImplOptions.AggressiveInlining)]
77      protected override ref LinksHeader<uint> GetHeaderReference() => ref *_header;
78
79      [MethodImpl(MethodImplOptions.AggressiveInlining)]
80      protected override ref RawLink<uint> GetLinkReference(uint linkIndex) => ref
81      → _links[linkIndex];
82
83      [MethodImpl(MethodImplOptions.AggressiveInlining)]
84      protected override bool AreEqual(uint first, uint second) => first == second;
85
86      [MethodImpl(MethodImplOptions.AggressiveInlining)]
87      protected override bool LessThan(uint first, uint second) => first < second;
88
89      [MethodImpl(MethodImplOptions.AggressiveInlining)]
90      protected override bool LessOrEqualThan(uint first, uint second) => first <= second;
91

```

```

80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     protected override bool GreaterThan(uint first, uint second) => first > second;
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override bool GreaterOrEqualThan(uint first, uint second) => first >= second;
85
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     protected override uint GetZero() => 0U;
88
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     protected override uint GetOne() => 1U;
91
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     protected override long ConvertToInt64(uint value) => (long)value;
94
95     [MethodImpl(MethodImplOptions.AggressiveInlining)]
96     protected override uint ConvertToAddress(long value) => (uint)value;
97
98     [MethodImpl(MethodImplOptions.AggressiveInlining)]
99     protected override uint Add(uint first, uint second) => first + second;
100
101     [MethodImpl(MethodImplOptions.AggressiveInlining)]
102     protected override uint Subtract(uint first, uint second) => first - second;
103
104     [MethodImpl(MethodImplOptions.AggressiveInlining)]
105     protected override uint Increment(uint link) => ++link;
106
107     [MethodImpl(MethodImplOptions.AggressiveInlining)]
108     protected override uint Decrement(uint link) => --link;
109 }
110 }

```

1.71 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32UnusedLinksListMethods.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Data.Doublets.Memory.United.Generic;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.United.Specific
7  {
8      public unsafe class UInt32UnusedLinksListMethods : UnusedLinksListMethods<uint>
9      {
10         private readonly RawLink<uint>* _links;
11         private readonly LinksHeader<uint>* _header;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public UInt32UnusedLinksListMethods(RawLink<uint>* links, LinksHeader<uint>* header)
15             : base((byte*)links, (byte*)header)
16         {
17             _links = links;
18             _header = header;
19         }
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref RawLink<uint> GetLinkReference(uint link) => ref _links[link];
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected override ref LinksHeader<uint> GetHeaderReference() => ref *_header;
26     }
27 }

```

1.72 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksAvlBalancedTreeMethodsBase.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Data.Doublets.Memory.United.Generic;
3  using static System.Runtime.CompilerServices.Unsafe;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Memory.United.Specific
8  {
9      public unsafe abstract class UInt64LinksAvlBalancedTreeMethodsBase :
10         ↳ LinksAvlBalancedTreeMethodsBase<ulong>
11      {
12         protected new readonly RawLink<ulong>* Links;
13         protected new readonly LinksHeader<ulong>* Header;
14
15         protected UInt64LinksAvlBalancedTreeMethodsBase(LinksConstants<ulong> constants,
16             ↳ RawLink<ulong>* links, LinksHeader<ulong>* header)
17             : base(constants, (byte*)links, (byte*)header)
18         {
19
20         }
21     }
22 }

```



```

17     Links = links;
18     Header = header;
19 }
20
21 [MethodImpl(MethodImplOptions.AggressiveInlining)]
22 protected override ulong GetZero() => OUL;
23
24 [MethodImpl(MethodImplOptions.AggressiveInlining)]
25 protected override bool EqualToZero(ulong value) => value == OUL;
26
27 [MethodImpl(MethodImplOptions.AggressiveInlining)]
28 protected override bool AreEqual(ulong first, ulong second) => first == second;
29
30 [MethodImpl(MethodImplOptions.AggressiveInlining)]
31 protected override bool GreaterThanZero(ulong value) => value > OUL;
32
33 [MethodImpl(MethodImplOptions.AggressiveInlining)]
34 protected override bool GreaterThan(ulong first, ulong second) => first > second;
35
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
38
39 [MethodImpl(MethodImplOptions.AggressiveInlining)]
40 protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
    ↳ always true for ulong
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected override bool LessOrEqualThanZero(ulong value) => value == OUL; // value is
    ↳ always >= 0 for ulong
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
    ↳ for ulong
50
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected override bool LessThan(ulong first, ulong second) => first < second;
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 protected override ulong Increment(ulong value) => ++value;
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 protected override ulong Decrement(ulong value) => --value;
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected override ulong Add(ulong first, ulong second) => first + second;
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 protected override ulong Subtract(ulong first, ulong second) => first - second;
65
66 [MethodImpl(MethodImplOptions.AggressiveInlining)]
67 protected override bool FirstIsToLeftOfSecond(ulong first, ulong second)
68 {
69     ref var firstLink = ref Links[first];
70     ref var secondLink = ref Links[second];
71     return FirstIsToLeftOfSecond(firstLink.Source, firstLink.Target,
    ↳ secondLink.Source, secondLink.Target);
72 }
73
74 [MethodImpl(MethodImplOptions.AggressiveInlining)]
75 protected override bool FirstIsToTheRightOfSecond(ulong first, ulong second)
76 {
77     ref var firstLink = ref Links[first];
78     ref var secondLink = ref Links[second];
79     return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
    ↳ secondLink.Source, secondLink.Target);
80 }
81
82 [MethodImpl(MethodImplOptions.AggressiveInlining)]
83 protected override ulong GetSizeValue(ulong value) => (value & 4294967264UL) >> 5;
84
85 [MethodImpl(MethodImplOptions.AggressiveInlining)]
86 protected override void SetSizeValue(ref ulong storedValue, ulong size) => storedValue =
    ↳ storedValue & 31UL | (size & 134217727UL) << 5;
87
88 [MethodImpl(MethodImplOptions.AggressiveInlining)]
89 protected override bool GetLeftIsChildValue(ulong value) => (value & 16UL) >> 4 == 1UL;

```

```

90 [MethodImpl(MethodImplOptions.AggressiveInlining)]
91 protected override void SetLeftIsChildValue(ref ulong storedValue, bool value) =>
92     ↳ storedValue = storedValue & 4294967279UL | (As<bool, byte>(ref value) & 1UL) << 4;
93
94 [MethodImpl(MethodImplOptions.AggressiveInlining)]
95 protected override bool GetRightIsChildValue(ulong value) => (value & 8UL) >> 3 == 1UL;
96
97 [MethodImpl(MethodImplOptions.AggressiveInlining)]
98 protected override void SetRightIsChildValue(ref ulong storedValue, bool value) =>
99     ↳ storedValue = storedValue & 4294967287UL | (As<bool, byte>(ref value) & 1UL) << 3;
100
101 [MethodImpl(MethodImplOptions.AggressiveInlining)]
102 protected override sbyte GetBalanceValue(ulong value) => unchecked((sbyte)(value & 7UL |
103     ↳ 0xF8UL * ((value & 4UL) >> 2))); // if negative, then continue ones to the end of
104     ↳ sbyte
105
106 [MethodImpl(MethodImplOptions.AggressiveInlining)]
107 protected override void SetBalanceValue(ref ulong storedValue, sbyte value) =>
108     ↳ storedValue = unchecked(storedValue & 4294967288UL | (ulong)((byte)value >> 5 & 4 |
109     ↳ value & 3) & 7UL);
110
111 [MethodImpl(MethodImplOptions.AggressiveInlining)]
112 protected override ref LinksHeader<ulong> GetHeaderReference() => ref *Header;
113
114 [MethodImpl(MethodImplOptions.AggressiveInlining)]
115 protected override ref RawLink<ulong> GetLinkReference(ulong link) => ref Links[link];
116 }
117 }

```

1.73 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSizeBalancedTreeMethodsBase.cs

```

1 using System.Runtime.CompilerServices;
2 using Platform.Data.Doublets.Memory.United.Generic;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Data.Doublets.Memory.United.Specific
7 {
8     public unsafe abstract class UInt64LinksSizeBalancedTreeMethodsBase :
9         ↳ LinksSizeBalancedTreeMethodsBase<ulong>
10     {
11         protected new readonly RawLink<ulong>* Links;
12         protected new readonly LinksHeader<ulong>* Header;
13
14         protected UInt64LinksSizeBalancedTreeMethodsBase(LinksConstants<ulong> constants,
15             ↳ RawLink<ulong>* links, LinksHeader<ulong>* header)
16             : base(constants, (byte*)links, (byte*)header)
17         {
18             Links = links;
19             Header = header;
20         }
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ulong GetZero() => 0UL;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override bool EqualToZero(ulong value) => value == 0UL;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override bool AreEqual(ulong first, ulong second) => first == second;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override bool GreaterThanZero(ulong value) => value > 0UL;
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected override bool GreaterThan(ulong first, ulong second) => first > second;
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
42             ↳ always true for ulong
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
46             ↳ always >= 0 for ulong
47
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

45     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
    ↪ for ulong
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool LessThan(ulong first, ulong second) => first < second;
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     protected override ulong Increment(ulong value) => ++value;
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     protected override ulong Decrement(ulong value) => --value;
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     protected override ulong Add(ulong first, ulong second) => first + second;
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     protected override ulong Subtract(ulong first, ulong second) => first - second;
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override bool FirstIsToTheLeftOfSecond(ulong first, ulong second)
67     {
68         ref var firstLink = ref Links[first];
69         ref var secondLink = ref Links[second];
70         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
    ↪ secondLink.Source, secondLink.Target);
71     }
72
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     protected override bool FirstIsToTheRightOfSecond(ulong first, ulong second)
75     {
76         ref var firstLink = ref Links[first];
77         ref var secondLink = ref Links[second];
78         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
    ↪ secondLink.Source, secondLink.Target);
79     }
80
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     protected override ref LinksHeader<ulong> GetHeaderReference() => ref *Header;
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     protected override ref RawLink<ulong> GetLinkReference(ulong link) => ref Links[link];
86 }
87 }

```

1.74 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSourcesAvlBalancedTreeMethods.cs

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Data.Doublets.Memory.United.Specific
6  {
7      public unsafe class UInt64LinksSourcesAvlBalancedTreeMethods :
    ↪ UInt64LinksAvlBalancedTreeMethodsBase
8      {
9          public UInt64LinksSourcesAvlBalancedTreeMethods(LinksConstants<ulong> constants,
    ↪ RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants, links, header)
    ↪ { }
10
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         protected override ref ulong GetLeftReference(ulong node) => ref
    ↪ Links[node].LeftAsSource;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref ulong GetRightReference(ulong node) => ref
    ↪ Links[node].RightAsSource;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ulong GetLeft(ulong node) => Links[node].LeftAsSource;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override ulong GetRight(ulong node) => Links[node].RightAsSource;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsSource =
    ↪ left;
25

```

```

26 [MethodImpl(MethodImplOptions.AggressiveInlining)]
27 protected override void SetRight(ulong node, ulong right) => Links[node].RightAsSource =
    ↳ right;
28
29 [MethodImpl(MethodImplOptions.AggressiveInlining)]
30 protected override ulong GetSize(ulong node) => GetSizeValue(Links[node].SizeAsSource);
31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 protected override void SetSize(ulong node, ulong size) => SetSizeValue(ref
    ↳ Links[node].SizeAsSource, size);
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 protected override bool GetLeftIsChild(ulong node) =>
    ↳ GetLeftIsChildValue(Links[node].SizeAsSource);
37
38 // [MethodImpl(MethodImplOptions.AggressiveInlining)]
39 // protected override bool GetLeftIsChild(ulong node) => IsChild(node, GetLeft(node));
40
41 [MethodImpl(MethodImplOptions.AggressiveInlining)]
42 protected override void SetLeftIsChild(ulong node, bool value) =>
    ↳ SetLeftIsChildValue(ref Links[node].SizeAsSource, value);
43
44 [MethodImpl(MethodImplOptions.AggressiveInlining)]
45 protected override bool GetRightIsChild(ulong node) =>
    ↳ GetRightIsChildValue(Links[node].SizeAsSource);
46
47 // [MethodImpl(MethodImplOptions.AggressiveInlining)]
48 // protected override bool GetRightIsChild(ulong node) => IsChild(node, GetRight(node));
49
50 [MethodImpl(MethodImplOptions.AggressiveInlining)]
51 protected override void SetRightIsChild(ulong node, bool value) =>
    ↳ SetRightIsChildValue(ref Links[node].SizeAsSource, value);
52
53 [MethodImpl(MethodImplOptions.AggressiveInlining)]
54 protected override sbyte GetBalance(ulong node) =>
    ↳ GetBalanceValue(Links[node].SizeAsSource);
55
56 [MethodImpl(MethodImplOptions.AggressiveInlining)]
57 protected override void SetBalance(ulong node, sbyte value) => SetBalanceValue(ref
    ↳ Links[node].SizeAsSource, value);
58
59 [MethodImpl(MethodImplOptions.AggressiveInlining)]
60 protected override ulong GetTreeRoot() => Header->RootAsSource;
61
62 [MethodImpl(MethodImplOptions.AggressiveInlining)]
63 protected override ulong GetBasePartValue(ulong link) => Links[link].Source;
64
65 [MethodImpl(MethodImplOptions.AggressiveInlining)]
66 protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
    ↳ ulong secondSource, ulong secondTarget)
67     => firstSource < secondSource || (firstSource == secondSource && firstTarget <
    ↳ secondTarget);
68
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
    ↳ ulong secondSource, ulong secondTarget)
71     => firstSource > secondSource || (firstSource == secondSource && firstTarget >
    ↳ secondTarget);
72
73 [MethodImpl(MethodImplOptions.AggressiveInlining)]
74 protected override void ClearNode(ulong node)
75 {
76     ref var link = ref Links[node];
77     link.LeftAsSource = OUL;
78     link.RightAsSource = OUL;
79     link.SizeAsSource = OUL;
80 }
81 }
82 }

```

1.75 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSourcesSizeBalancedTreeMethods.cs

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Memory.United.Specific
6 {
7     public unsafe class UInt64LinksSourcesSizeBalancedTreeMethods :
    ↳ UInt64LinksSizeBalancedTreeMethodsBase

```

```

8 {
9     public UInt64LinksSourcesSizeBalancedTreeMethods(LinksConstants<ulong> constants,
10         ↪ RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants, links, header)
11         ↪ { }
12
13     [MethodImpl(MethodImplOptions.AggressiveInlining)]
14     protected override ref ulong GetLeftReference(ulong node) => ref
15         ↪ Links[node].LeftAsSource;
16
17     [MethodImpl(MethodImplOptions.AggressiveInlining)]
18     protected override ref ulong GetRightReference(ulong node) => ref
19         ↪ Links[node].RightAsSource;
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override ulong GetLeft(ulong node) => Links[node].LeftAsSource;
23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsSource =
26         ↪ left;
27
28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override void SetRight(ulong node, ulong right) => Links[node].RightAsSource =
30         ↪ right;
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     protected override ulong GetSize(ulong node) => Links[node].SizeAsSource;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override void SetSize(ulong node, ulong size) => Links[node].SizeAsSource =
37         ↪ size;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override ulong GetTreeRoot() => Header->RootAsSource;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override ulong GetBasePartValue(ulong link) => Links[link].Source;
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
47         ↪ ulong secondSource, ulong secondTarget)
48         => firstSource < secondSource || (firstSource == secondSource && firstTarget <
49         ↪ secondTarget);
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
53         ↪ ulong secondSource, ulong secondTarget)
54         => firstSource > secondSource || (firstSource == secondSource && firstTarget >
55         ↪ secondTarget);
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override void ClearNode(ulong node)
59     {
60         ref var link = ref Links[node];
61         link.LeftAsSource = OUL;
62         link.RightAsSource = OUL;
63         link.SizeAsSource = OUL;
64     }
65 }

```

1.76 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksTargetsAvlBalancedTreeMethods.cs

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Memory.United.Specific
6 {
7     public unsafe class UInt64LinksTargetsAvlBalancedTreeMethods :
8         ↪ UInt64LinksAvlBalancedTreeMethodsBase
9     {
10         public UInt64LinksTargetsAvlBalancedTreeMethods(LinksConstants<ulong> constants,
11             ↪ RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants, links, header)
12             ↪ { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

12     protected override ref ulong GetLeftReference(ulong node) => ref
13         ↳ Links[node].LeftAsTarget;
14
15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     protected override ref ulong GetRightReference(ulong node) => ref
17         ↳ Links[node].RightAsTarget;
18
19     [MethodImpl(MethodImplOptions.AggressiveInlining)]
20     protected override ulong GetLeft(ulong node) => Links[node].LeftAsTarget;
21
22     [MethodImpl(MethodImplOptions.AggressiveInlining)]
23     protected override ulong GetRight(ulong node) => Links[node].RightAsTarget;
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsTarget =
27         ↳ left;
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected override void SetRight(ulong node, ulong right) => Links[node].RightAsTarget =
31         ↳ right;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override ulong GetSize(ulong node) => GetSizeValue(Links[node].SizeAsTarget);
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override void SetSize(ulong node, ulong size) => SetSizeValue(ref
38         ↳ Links[node].SizeAsTarget, size);
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override bool GetLeftIsChild(ulong node) =>
42         ↳ GetLeftIsChildValue(Links[node].SizeAsTarget);
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override void SetLeftIsChild(ulong node, bool value) =>
46         ↳ SetLeftIsChildValue(ref Links[node].SizeAsTarget, value);
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override bool GetRightIsChild(ulong node) =>
50         ↳ GetRightIsChildValue(Links[node].SizeAsTarget);
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected override void SetRightIsChild(ulong node, bool value) =>
54         ↳ SetRightIsChildValue(ref Links[node].SizeAsTarget, value);
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     protected override sbyte GetBalance(ulong node) =>
58         ↳ GetBalanceValue(Links[node].SizeAsTarget);
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override void SetBalance(ulong node, sbyte value) => SetBalanceValue(ref
62         ↳ Links[node].SizeAsTarget, value);
63
64     [MethodImpl(MethodImplOptions.AggressiveInlining)]
65     protected override ulong GetTreeRoot() => Header->RootAsTarget;
66
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     protected override ulong GetBasePartValue(ulong link) => Links[link].Target;
69
70     [MethodImpl(MethodImplOptions.AggressiveInlining)]
71     protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
72         ↳ ulong secondSource, ulong secondTarget)
73         => firstTarget < secondTarget || (firstTarget == secondTarget && firstSource <
74         ↳ secondSource);
75
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
78         ↳ ulong secondSource, ulong secondTarget)
79         => firstTarget > secondTarget || (firstTarget == secondTarget && firstSource >
80         ↳ secondSource);
81
82     [MethodImpl(MethodImplOptions.AggressiveInlining)]
83     protected override void ClearNode(ulong node)
84     {
85         ref var link = ref Links[node];
86         link.LeftAsTarget = OUL;
87         link.RightAsTarget = OUL;
88         link.SizeAsTarget = OUL;
89     }

```

```

75     }
76 }

```

1.77 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksTargetsSizeBalancedTreeMethods.cs

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Data.Doublets.Memory.United.Specific
6  {
7      public unsafe class UInt64LinksTargetsSizeBalancedTreeMethods :
8          ↳ UInt64LinksSizeBalancedTreeMethodsBase
9      {
10         public UInt64LinksTargetsSizeBalancedTreeMethods(LinksConstants<ulong> constants,
11             ↳ RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants, links, header)
12             ↳ { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref ulong GetLeftReference(ulong node) => ref
16             ↳ Links[node].LeftAsTarget;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref ulong GetRightReference(ulong node) => ref
20             ↳ Links[node].RightAsTarget;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ulong GetLeft(ulong node) => Links[node].LeftAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override ulong GetRight(ulong node) => Links[node].RightAsTarget;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsTarget =
30             ↳ left;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetRight(ulong node, ulong right) => Links[node].RightAsTarget =
34             ↳ right;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override ulong GetSize(ulong node) => Links[node].SizeAsTarget;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override void SetSize(ulong node, ulong size) => Links[node].SizeAsTarget =
41             ↳ size;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override ulong GetTreeRoot() => Header->RootAsTarget;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override ulong GetBasePartValue(ulong link) => Links[link].Target;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
51             ↳ ulong secondSource, ulong secondTarget)
52             ↳ => firstTarget < secondTarget || (firstTarget == secondTarget && firstSource <
53                 ↳ secondSource);
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
57             ↳ ulong secondSource, ulong secondTarget)
58             ↳ => firstTarget > secondTarget || (firstTarget == secondTarget && firstSource >
59                 ↳ secondSource);
60
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         protected override void ClearNode(ulong node)
63         {
64             ref var link = ref Links[node];
65             link.LeftAsTarget = OUL;
66             link.RightAsTarget = OUL;
67             link.SizeAsTarget = OUL;
68         }
69     }
70 }

```

1.78 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64UnitedMemoryLinks.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Memory;

```

```

4 using Platform.Singletons;
5 using Platform.Data.Doublents.Memory.United.Generic;
6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublents.Memory.United.Specific
10 {
11     /// <summary>
12     /// <para>Represents a low-level implementation of direct access to resizable memory, for
13     ///     organizing the storage of links with addresses represented as <see cref="ulong">
14     ///     />.</para>
15     /// <para>Представляет низкоуровневую реализация прямого доступа к памяти с переменным
16     ///     размером, для организации хранения связей с адресами представленными в виде <see
17     ///     cref="ulong"/>.</para>
18     /// </summary>
19     public unsafe class UInt64UnitedMemoryLinks : UnitedMemoryLinksBase<ulong>
20     {
21         private readonly Func<ILinksTreeMethods<ulong>> _createSourceTreeMethods;
22         private readonly Func<ILinksTreeMethods<ulong>> _createTargetTreeMethods;
23         private LinksHeader<ulong>* _header;
24         private RawLink<ulong>* _links;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public UInt64UnitedMemoryLinks(string address) : this(address, DefaultLinksSizeStep) { }
28
29         /// <summary>
30         /// Создаёт экземпляр базы данных Links в файле по указанному адресу, с указанным
31         ///     минимальным шагом расширения базы данных.
32         /// </summary>
33         /// <param name="address">Полный путь к файлу базы данных.</param>
34         /// <param name="memoryReservationStep">Минимальный шаг расширения базы данных в
35         ///     байтах.</param>
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public UInt64UnitedMemoryLinks(string address, long memoryReservationStep) : this(new
38             FileMappedResizableDirectMemory(address, memoryReservationStep),
39             memoryReservationStep) { }
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         public UInt64UnitedMemoryLinks(IResizableDirectMemory memory) : this(memory,
43             DefaultLinksSizeStep) { }
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public UInt64UnitedMemoryLinks(IResizableDirectMemory memory, long
47             memoryReservationStep) : this(memory, memoryReservationStep,
48             Default<LinksConstants<ulong>>.Instance, IndexTreeType.Default) { }
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         public UInt64UnitedMemoryLinks(IResizableDirectMemory memory, long
52             memoryReservationStep, LinksConstants<ulong> constants, IndexTreeType indexTreeType)
53             : base(memory, memoryReservationStep, constants)
54         {
55             if (indexTreeType == IndexTreeType.SizedAndThreadedAVLBalancedTree)
56             {
57                 _createSourceTreeMethods = () => new
58                     UInt64LinksSourcesAvlBalancedTreeMethods(Constants, _links, _header);
59                 _createTargetTreeMethods = () => new
60                     UInt64LinksTargetsAvlBalancedTreeMethods(Constants, _links, _header);
61             }
62             else
63             {
64                 _createSourceTreeMethods = () => new
65                     UInt64LinksSourcesSizeBalancedTreeMethods(Constants, _links, _header);
66                 _createTargetTreeMethods = () => new
67                     UInt64LinksTargetsSizeBalancedTreeMethods(Constants, _links, _header);
68             }
69             Init(memory, memoryReservationStep);
70         }
71
72         [MethodImpl(MethodImplOptions.AggressiveInlining)]
73         protected override void SetPointers(IResizableDirectMemory memory)
74         {
75             _header = (LinksHeader<ulong>*)memory.Pointer;
76             _links = (RawLink<ulong>*)memory.Pointer;
77             SourcesTreeMethods = _createSourceTreeMethods();
78             TargetsTreeMethods = _createTargetTreeMethods();
79             UnusedLinksListMethods = new UInt64UnusedLinksListMethods(_links, _header);
80         }
81     }
82 }

```



```

65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override void ResetPointers()
67     {
68         base.ResetPointers();
69         _links = null;
70         _header = null;
71     }
72
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     protected override ref LinksHeader<ulong> GetHeaderReference() => ref *_header;
75
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     protected override ref RawLink<ulong> GetLinkReference(ulong linkIndex) => ref
78         ↪ _links[linkIndex];
79
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     protected override bool AreEqual(ulong first, ulong second) => first == second;
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override bool LessThan(ulong first, ulong second) => first < second;
85
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
88
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     protected override bool GreaterThan(ulong first, ulong second) => first > second;
91
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
94
95     [MethodImpl(MethodImplOptions.AggressiveInlining)]
96     protected override ulong GetZero() => 0UL;
97
98     [MethodImpl(MethodImplOptions.AggressiveInlining)]
99     protected override ulong GetOne() => 1UL;
100
101     [MethodImpl(MethodImplOptions.AggressiveInlining)]
102     protected override long ConvertToInt64(ulong value) => (long)value;
103
104     [MethodImpl(MethodImplOptions.AggressiveInlining)]
105     protected override ulong ConvertToAddress(long value) => (ulong)value;
106
107     [MethodImpl(MethodImplOptions.AggressiveInlining)]
108     protected override ulong Add(ulong first, ulong second) => first + second;
109
110     [MethodImpl(MethodImplOptions.AggressiveInlining)]
111     protected override ulong Subtract(ulong first, ulong second) => first - second;
112
113     [MethodImpl(MethodImplOptions.AggressiveInlining)]
114     protected override ulong Increment(ulong link) => ++link;
115
116     [MethodImpl(MethodImplOptions.AggressiveInlining)]
117     protected override ulong Decrement(ulong link) => --link;
118 }

```

1.79 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64UnusedLinksListMethods.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Data.Doublets.Memory.United.Generic;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Memory.United.Specific
7  {
8      public unsafe class UInt64UnusedLinksListMethods : UnusedLinksListMethods<ulong>
9      {
10         private readonly RawLink<ulong>* _links;
11         private readonly LinksHeader<ulong>* _header;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public UInt64UnusedLinksListMethods(RawLink<ulong>* links, LinksHeader<ulong>* header)
15             : base((byte*)links, (byte*)header)
16         {
17             _links = links;
18             _header = header;
19         }
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         protected override ref RawLink<ulong> GetLinkReference(ulong link) => ref _links[link];
23

```

```

24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override ref LinksHeader<ulong> GetHeaderReference() => ref *_header;
26 }
27 }

```

1.80 ./csharp/Platform.Data.Doublets/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     public class AddressToUnaryNumberConverter<TLink> : LinksOperatorBase<TLink>,
12         ⇨ IConverter<TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15             ⇨ EqualityComparer<TLink>.Default;
16         private static readonly TLink _zero = default;
17         private static readonly TLink _one = Arithmetic.Increment(_zero);
18
19         private readonly IConverter<int, TLink> _powerOf2ToUnaryNumberConverter;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public AddressToUnaryNumberConverter(ILinks<TLink> links, IConverter<int, TLink>
23             ⇨ powerOf2ToUnaryNumberConverter) : base(links) => _powerOf2ToUnaryNumberConverter =
24             ⇨ powerOf2ToUnaryNumberConverter;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public TLink Convert(TLink number)
28         {
29             var links = _links;
30             var nullConstant = links.Constants.Null;
31             var target = nullConstant;
32             for (var i = 0; !_equalityComparer.Equals(number, _zero) && i <
33                 ⇨ NumericType<TLink>.BitsSize; i++)
34             {
35                 if (_equalityComparer.Equals(Bit.And(number, _one), _one))
36                 {
37                     target = _equalityComparer.Equals(target, nullConstant)
38                         ? _powerOf2ToUnaryNumberConverter.Convert(i)
39                         : links.GetOrCreate(_powerOf2ToUnaryNumberConverter.Convert(i), target);
40                 }
41                 number = Bit.ShiftRight(number, 1);
42             }
43             return target;
44         }
45     }
46 }

```

1.81 ./csharp/Platform.Data.Doublets/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     public class LinkToItsFrequencyNumberConveter<TLink> : LinksOperatorBase<TLink>,
12         ⇨ IConverter<Doublet<TLink>, TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15             ⇨ EqualityComparer<TLink>.Default;
16
17         private readonly IProperty<TLink, TLink> _frequencyPropertyOperator;
18         private readonly IConverter<TLink> _unaryNumberToAddressConverter;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public LinkToItsFrequencyNumberConveter(
22             ILinks<TLink> links,
23             IProperty<TLink, TLink> frequencyPropertyOperator,
24             IConverter<TLink> unaryNumberToAddressConverter)
25             : base(links)
26         {
27
28         }
29     }
30 }

```

```

25     _frequencyPropertyOperator = frequencyPropertyOperator;
26     _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
27 }
28
29 [MethodImpl(MethodImplOptions.AggressiveInlining)]
30 public TLink Convert(Doublet<TLink> doublet)
31 {
32     var links = _links;
33     var link = links.SearchOrDefault(doublet.Source, doublet.Target);
34     if (_equalityComparer.Equals(link, default))
35     {
36         throw new ArgumentException($"Link ({doublet}) not found.", nameof(doublet));
37     }
38     var frequency = _frequencyPropertyOperator.Get(link);
39     if (_equalityComparer.Equals(frequency, default))
40     {
41         return default;
42     }
43     var frequencyNumber = links.GetSource(frequency);
44     return _unaryNumberToAddressConverter.Convert(frequencyNumber);
45 }
46 }
47 }

```

1.82 ./csharp/Platform.Data.Doublets/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     public class PowerOf2ToUnaryNumberConverter<TLink> : LinksOperatorBase<TLink>,
12         ↪ IConverter<int, TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15             ↪ EqualityComparer<TLink>.Default;
16
17         private readonly TLink[] _unaryNumberPowersOf2;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public PowerOf2ToUnaryNumberConverter(ILinks<TLink> links, TLink one) : base(links)
21         {
22             _unaryNumberPowersOf2 = new TLink[64];
23             _unaryNumberPowersOf2[0] = one;
24         }
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public TLink Convert(int power)
28         {
29             Ensure.Always.ArgumentInRange(power, new Range<int>(0, _unaryNumberPowersOf2.Length
30                 ↪ - 1), nameof(power));
31             if (!_equalityComparer.Equals(_unaryNumberPowersOf2[power], default))
32             {
33                 return _unaryNumberPowersOf2[power];
34             }
35             var previousPowerOf2 = Convert(power - 1);
36             var powerOf2 = _links.GetOrCreate(previousPowerOf2, previousPowerOf2);
37             _unaryNumberPowersOf2[power] = powerOf2;
38             return powerOf2;
39         }
40     }
41 }

```

1.83 ./csharp/Platform.Data.Doublets/Numbers/Unary/UnaryNumberToAddressAddOperationConverter.cs

```

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     public class UnaryNumberToAddressAddOperationConverter<TLink> : LinksOperatorBase<TLink>,
11         ↪ IConverter<TLink>

```

```

11 {
12     private static readonly EqualityComparer<TLink> _equalityComparer =
13         ↳ EqualityComparer<TLink>.Default;
14     private static readonly uncheckedConverter<TLink, ulong> _addressToUInt64Converter =
15         ↳ uncheckedConverter<TLink, ulong>.Default;
16     private static readonly uncheckedConverter<ulong, TLink> _uint64ToAddressConverter =
17         ↳ uncheckedConverter<ulong, TLink>.Default;
18     private static readonly TLink _zero = default;
19     private static readonly TLink _one = Arithmetic.Increment(_zero);
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     public UnaryNumberToAddressAddOperationConverter(ILinks<TLink> links, TLink unaryOne)
23         : base(links)
24     {
25         _unaryOne = unaryOne;
26         _unaryToUInt64 = CreateUnaryToUInt64Dictionary(links, unaryOne);
27     }
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     public TLink Convert(TLink unaryNumber)
31     {
32         if (_equalityComparer.Equals(unaryNumber, default))
33         {
34             return default;
35         }
36         if (_equalityComparer.Equals(unaryNumber, _unaryOne))
37         {
38             return _one;
39         }
40         var links = _links;
41         var source = links.GetSource(unaryNumber);
42         var target = links.GetTarget(unaryNumber);
43         if (_equalityComparer.Equals(source, target))
44         {
45             return _unaryToUInt64[unaryNumber];
46         }
47         else
48         {
49             var result = _unaryToUInt64[source];
50             TLink lastValue;
51             while (!_unaryToUInt64.TryGetValue(target, out lastValue))
52             {
53                 source = links.GetSource(target);
54                 result = Arithmetic<TLink>.Add(result, _unaryToUInt64[source]);
55                 target = links.GetTarget(target);
56             }
57             result = Arithmetic<TLink>.Add(result, lastValue);
58             return result;
59         }
60     }
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     private static Dictionary<TLink, TLink> CreateUnaryToUInt64Dictionary(ILinks<TLink>
64         ↳ links, TLink unaryOne)
65     {
66         var unaryToUInt64 = new Dictionary<TLink, TLink>
67         {
68             { unaryOne, _one }
69         };
70         var unary = unaryOne;
71         var number = _one;
72         for (var i = 1; i < 64; i++)
73         {
74             unary = links.GetOrCreate(unary, unary);
75             number = Double(number);
76             unaryToUInt64.Add(unary, number);
77         }
78         return unaryToUInt64;
79     }
80
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     private static TLink Double(TLink number) =>
83         ↳ _uint64ToAddressConverter.Convert(_addressToUInt64Converter.Convert(number) * 2UL);
84 }

```

1.84 ./csharp/Platform.Data.Doublets/Numbers/Unary/UnaryNumberToAddressOrOperationConverter.cs

```

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     public class UnaryNumberToAddressOrOperationConverter<TLink> : LinksOperatorBase<TLink>,
12         ⇨ IConverter<TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15             ⇨ EqualityComparer<TLink>.Default;
16         private static readonly TLink _zero = default;
17         private static readonly TLink _one = Arithmetic.Increment(_zero);
18
19         private readonly IDictionary<TLink, int> _unaryNumberPowerOf2Indicies;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public UnaryNumberToAddressOrOperationConverter(ILinks<TLink> links, IConverter<int,
23             ⇨ TLink> powerOf2ToUnaryNumberConverter) : base(links) => _unaryNumberPowerOf2Indicies
24             ⇨ = CreateUnaryNumberPowerOf2IndiciesDictionary(powerOf2ToUnaryNumberConverter);
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public TLink Convert(TLink sourceNumber)
28         {
29             var links = _links;
30             var nullConstant = links.Constants.Null;
31             var source = sourceNumber;
32             var target = nullConstant;
33             if (!_equalityComparer.Equals(source, nullConstant))
34             {
35                 while (true)
36                 {
37                     if (_unaryNumberPowerOf2Indicies.TryGetValue(source, out int powerOf2Index))
38                     {
39                         SetBit(ref target, powerOf2Index);
40                         break;
41                     }
42                     else
43                     {
44                         powerOf2Index = _unaryNumberPowerOf2Indicies[links.GetSource(source)];
45                         SetBit(ref target, powerOf2Index);
46                         source = links.GetTarget(source);
47                     }
48                 }
49             }
50             return target;
51         }
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         private static Dictionary<TLink, int>
55             ⇨ CreateUnaryNumberPowerOf2IndiciesDictionary(IConverter<int, TLink>
56             ⇨ powerOf2ToUnaryNumberConverter)
57         {
58             var unaryNumberPowerOf2Indicies = new Dictionary<TLink, int>();
59             for (int i = 0; i < NumericType<TLink>.BitsSize; i++)
60             {
61                 unaryNumberPowerOf2Indicies.Add(powerOf2ToUnaryNumberConverter.Convert(i), i);
62             }
63             return unaryNumberPowerOf2Indicies;
64         }
65
66         [MethodImpl(MethodImplOptions.AggressiveInlining)]
67         private static void SetBit(ref TLink target, int powerOf2Index) => target =
68             ⇨ Bit.Or(target, Bit.ShiftLeft(_one, powerOf2Index));
69     }
70 }

```

1.85 ./csharp/Platform.Data.Doublets/PropertyOperators/PropertiesOperator.cs

```

1  using System.Linq;
2  using System.Collections.Generic;
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.PropertyOperators
9 {
10     public class PropertiesOperator<TLink> : LinksOperatorBase<TLink>, IProperties<TLink, TLink,
        ↪ TLink>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
            ↪ EqualityComparer<TLink>.Default;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public PropertiesOperator(ILinks<TLink> links) : base(links) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public TLink GetValue(TLink @object, TLink property)
19         {
20             var links = _links;
21             var objectProperty = links.SearchOrDefault(@object, property);
22             if (_equalityComparer.Equals(objectProperty, default))
23             {
24                 return default;
25             }
26             var constants = links.Constants;
27             var valueLink = links.All(constants.Any, objectProperty).SingleOrDefault();
28             if (valueLink == null)
29             {
30                 return default;
31             }
32             return links.GetTarget(valueLink[constants.IndexPart]);
33         }
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         public void SetValue(TLink @object, TLink property, TLink value)
37         {
38             var links = _links;
39             var objectProperty = links.GetOrCreate(@object, property);
40             links.DeleteMany(links.AllIndices(links.Constants.Any, objectProperty));
41             links.GetOrCreate(objectProperty, value);
42         }
43     }
44 }

```

1.86 ./csharp/Platform.Data.Doublets/PropertyOperators/PropertyOperator.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.PropertyOperators
8 {
9     public class PropertyOperator<TLink> : LinksOperatorBase<TLink>, IProperty<TLink, TLink>
10     {
11         private static readonly EqualityComparer<TLink> _equalityComparer =
            ↪ EqualityComparer<TLink>.Default;
12
13         private readonly TLink _propertyMarker;
14         private readonly TLink _propertyValueMarker;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public PropertyOperator(ILinks<TLink> links, TLink propertyMarker, TLink
            ↪ propertyValueMarker) : base(links)
18         {
19             _propertyMarker = propertyMarker;
20             _propertyValueMarker = propertyValueMarker;
21         }
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public TLink Get(TLink link)
25         {
26             var property = _links.SearchOrDefault(link, _propertyMarker);
27             return GetValue(GetContainer(property));
28         }
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         private TLink GetContainer(TLink property)
32         {
33             var valueContainer = default(TLink);
34             if (_equalityComparer.Equals(property, default))
35             {
36                 return valueContainer;
37             }
38         }
39     }
40 }

```

```

38     var links = _links;
39     var constants = links.Constants;
40     var countinueConstant = constants.Continue;
41     var breakConstant = constants.Break;
42     var anyConstant = constants.Any;
43     var query = new Link<TLink>(anyConstant, property, anyConstant);
44     links.Each(candidate =>
45     {
46         var candidateTarget = links.GetTarget(candidate);
47         var valueTarget = links.GetTarget(candidateTarget);
48         if (_equalityComparer.Equals(valueTarget, _propertyValueMarker))
49         {
50             valueContainer = links.GetIndex(candidate);
51             return breakConstant;
52         }
53         return countinueConstant;
54     }, query);
55     return valueContainer;
56 }
57
58 [MethodImpl(MethodImplOptions.AggressiveInlining)]
59 private TLink GetValue(TLink container) => _equalityComparer.Equals(container, default)
    ↪ ? default : _links.GetTarget(container);
60
61 [MethodImpl(MethodImplOptions.AggressiveInlining)]
62 public void Set(TLink link, TLink value)
63 {
64     var links = _links;
65     var property = links.GetOrCreate(link, _propertyMarker);
66     var container = GetContainer(property);
67     if (_equalityComparer.Equals(container, default))
68     {
69         links.GetOrCreate(property, value);
70     }
71     else
72     {
73         links.Update(container, property, value);
74     }
75 }
76 }
77 }

```

1.87 ./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      public class BalancedVariantConverter<TLink> : LinksListToSequenceConverterBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public BalancedVariantConverter(ILinks<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public override TLink Convert(ICollection<TLink> sequence)
15         {
16             var length = sequence.Count;
17             if (length < 1)
18             {
19                 return default;
20             }
21             if (length == 1)
22             {
23                 return sequence[0];
24             }
25             // Make copy of next layer
26             if (length > 2)
27             {
28                 // TODO: Try to use stackalloc (which at the moment is not working with
29                 ↪ generics) but will be possible with Sigil
30                 var halvedSequence = new TLink[(length / 2) + (length % 2)];
31                 HalveSequence(halvedSequence, sequence, length);
32                 sequence = halvedSequence;
33                 length = halvedSequence.Length;
34             }
35             // Keep creating layer after layer
36             while (length > 2)

```

```

36     {
37         HalveSequence(sequence, sequence, length);
38         length = (length / 2) + (length % 2);
39     }
40     return _links.GetOrCreate(sequence[0], sequence[1]);
41 }
42
43 [MethodImpl(MethodImplOptions.AggressiveInlining)]
44 private void HalveSequence(ICollection<TLink> destination, ICollection<TLink> source, int length)
45 {
46     var loopedLength = length - (length % 2);
47     for (var i = 0; i < loopedLength; i += 2)
48     {
49         destination[i / 2] = _links.GetOrCreate(source[i], source[i + 1]);
50     }
51     if (length > loopedLength)
52     {
53         destination[length / 2] = source[length - 1];
54     }
55 }
56 }
57 }

```

1.88 ./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
30         private static readonly TLink _zero = default;
31         private static readonly TLink _one = Arithmetic.Increment(_zero);
32
33         private readonly IConverter<ICollection<TLink>, TLink> _baseConverter;
34         private readonly LinkFrequenciesCache<TLink> _doubletFrequenciesCache;
35         private readonly TLink _minFrequencyToCompress;
36         private readonly bool _doInitialFrequenciesIncrement;
37         private Doublet<TLink> _maxDoublet;
38         private LinkFrequency<TLink> _maxDoubletData;
39
40         private struct HalfDoublet
41         {
42             public TLink Element;
43             public LinkFrequency<TLink> DoubletData;
44
45             [MethodImpl(MethodImplOptions.AggressiveInlining)]
46             public HalfDoublet(TLink element, LinkFrequency<TLink> doubletData)
47             {
48                 Element = element;
49                 DoubletData = doubletData;
50             }
51
52             public override string ToString() => $"{Element}: ({DoubletData})";
53         }
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         public CompressingConverter(ICollection<TLink> links, IConverter<ICollection<TLink>, TLink>
57             ↪ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache)

```



```

52         : this(links, baseConverter, doubletFrequenciesCache, _one, true) { }
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
    ↳ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, bool
    ↳ doInitialFrequenciesIncrement)
56     : this(links, baseConverter, doubletFrequenciesCache, _one,
    ↳ doInitialFrequenciesIncrement) { }
57
58 [MethodImpl(MethodImplOptions.AggressiveInlining)]
59 public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
    ↳ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, TLink
    ↳ minFrequencyToCompress, bool doInitialFrequenciesIncrement)
60     : base(links)
61 {
62     _baseConverter = baseConverter;
63     _doubletFrequenciesCache = doubletFrequenciesCache;
64     if (_comparer.Compare(minFrequencyToCompress, _one) < 0)
65     {
66         minFrequencyToCompress = _one;
67     }
68     _minFrequencyToCompress = minFrequencyToCompress;
69     _doInitialFrequenciesIncrement = doInitialFrequenciesIncrement;
70     ResetMaxDoublet();
71 }
72
73 [MethodImpl(MethodImplOptions.AggressiveInlining)]
74 public override TLink Convert(IList<TLink> source) =>
    ↳ _baseConverter.Convert(Compress(source));
75
76 /// <remarks>
77 /// Original algorithm idea: https://en.wikipedia.org/wiki/Byte\_pair\_encoding .
78 /// Faster version (doublets' frequencies dictionary is not recreated).
79 /// </remarks>
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 private IList<TLink> Compress(IList<TLink> sequence)
82 {
83     if (sequence.IsNullOrEmpty())
84     {
85         return null;
86     }
87     if (sequence.Count == 1)
88     {
89         return sequence;
90     }
91     if (sequence.Count == 2)
92     {
93         return new[] { _links.GetOrCreate(sequence[0], sequence[1]) };
94     }
95     // TODO: arraypool with min size (to improve cache locality) or stackalloc with Sigil
96     var copy = new HalfDoublet[sequence.Count];
97     Doublet<TLink> doublet = default;
98     for (var i = 1; i < sequence.Count; i++)
99     {
100         doublet = new Doublet<TLink>(sequence[i - 1], sequence[i]);
101         LinkFrequency<TLink> data;
102         if (_doInitialFrequenciesIncrement)
103         {
104             data = _doubletFrequenciesCache.IncrementFrequency(ref doublet);
105         }
106         else
107         {
108             data = _doubletFrequenciesCache.GetFrequency(ref doublet);
109             if (data == null)
110             {
111                 throw new NotSupportedException("If you ask not to increment
    ↳ frequencies, it is expected that all frequencies for the sequence
    ↳ are prepared.");
112             }
113             copy[i - 1].Element = sequence[i - 1];
114             copy[i - 1].DoubletData = data;
115             UpdateMaxDoublet(ref doublet, data);
116         }
117     }
118     copy[sequence.Count - 1].Element = sequence[sequence.Count - 1];
119     copy[sequence.Count - 1].DoubletData = new LinkFrequency<TLink>();
120     if (_comparer.Compare(_maxDoubletData.Frequency, default) > 0)
121     {

```

```

122     var newLength = ReplaceDoublets(copy);
123     sequence = new TLink[newLength];
124     for (int i = 0; i < newLength; i++)
125     {
126         sequence[i] = copy[i].Element;
127     }
128 }
129 return sequence;
130 }
131
132 /// <remarks>
133 /// Original algorithm idea: https://en.wikipedia.org/wiki/Byte\_pair\_encoding
134 /// </remarks>
135 [MethodImpl(MethodImplOptions.AggressiveInlining)]
136 private int ReplaceDoublets(HalfDoublet[] copy)
137 {
138     var oldLength = copy.Length;
139     var newLength = copy.Length;
140     while (_comparer.Compare(_maxDoubletData.Frequency, default) > 0)
141     {
142         var maxDoubletSource = _maxDoublet.Source;
143         var maxDoubletTarget = _maxDoublet.Target;
144         if (_equalityComparer.Equals(_maxDoubletData.Link, _constants.Null))
145         {
146             _maxDoubletData.Link = _links.GetOrCreate(maxDoubletSource,
147                 ↪ maxDoubletTarget);
148         }
149         var maxDoubletReplacementLink = _maxDoubletData.Link;
150         oldLength--;
151         var oldLengthMinusTwo = oldLength - 1;
152         // Substitute all usages
153         int w = 0, r = 0; // (r == read, w == write)
154         for (; r < oldLength; r++)
155         {
156             if (_equalityComparer.Equals(copy[r].Element, maxDoubletSource) &&
157                 ↪ _equalityComparer.Equals(copy[r + 1].Element, maxDoubletTarget))
158             {
159                 if (r > 0)
160                 {
161                     var previous = copy[w - 1].Element;
162                     copy[w - 1].DoubletData.DecrementFrequency();
163                     copy[w - 1].DoubletData =
164                         ↪ _doubletFrequenciesCache.IncrementFrequency(previous,
165                             ↪ maxDoubletReplacementLink);
166                 }
167                 if (r < oldLengthMinusTwo)
168                 {
169                     var next = copy[r + 2].Element;
170                     copy[r + 1].DoubletData.DecrementFrequency();
171                     copy[w].DoubletData = _doubletFrequenciesCache.IncrementFrequency(maxDoubletSource,
172                         ↪ maxDoubletReplacementLink,
173                         ↪ next);
174                 }
175                 copy[w++].Element = maxDoubletReplacementLink;
176                 r++;
177                 newLength--;
178             }
179             else
180             {
181                 copy[w++] = copy[r];
182             }
183         }
184         if (w < newLength)
185         {
186             copy[w] = copy[r];
187         }
188         oldLength = newLength;
189         ResetMaxDoublet();
190         UpdateMaxDoublet(copy, newLength);
191     }
192     return newLength;
193 }
194
195 [MethodImpl(MethodImplOptions.AggressiveInlining)]
196 private void ResetMaxDoublet()
197 {
198     _maxDoublet = new Doublet<TLink>();
199     _maxDoubletData = new LinkFrequency<TLink>();
200 }

```

```

194     }
195
196     [MethodImpl(MethodImplOptions.AggressiveInlining)]
197     private void UpdateMaxDoublet(HalfDoublet[] copy, int length)
198     {
199         Doublet<TLink> doublet = default;
200         for (var i = 1; i < length; i++)
201         {
202             doublet = new Doublet<TLink>(copy[i - 1].Element, copy[i].Element);
203             UpdateMaxDoublet(ref doublet, copy[i - 1].DoubletData);
204         }
205     }
206
207     [MethodImpl(MethodImplOptions.AggressiveInlining)]
208     private void UpdateMaxDoublet(ref Doublet<TLink> doublet, LinkFrequency<TLink> data)
209     {
210         var frequency = data.Frequency;
211         var maxFrequency = _maxDoubletData.Frequency;
212         //if (frequency > _minFrequencyToCompress && (maxFrequency < frequency ||
213         ↪ (maxFrequency == frequency && doublet.Source + doublet.Target < /* gives better
214         ↪ compression string data (and gives collisions quickly) */ _maxDoublet.Source +
215         ↪ _maxDoublet.Target)))
216         if (_comparer.Compare(frequency, _minFrequencyToCompress) > 0 &&
217             (_comparer.Compare(maxFrequency, frequency) < 0 ||
218             ↪ (_equalityComparer.Equals(maxFrequency, frequency) &&
219             ↪ _comparer.Compare(Arithmetic.Add(doublet.Source, doublet.Target),
220             ↪ Arithmetic.Add(_maxDoublet.Source, _maxDoublet.Target)) > 0))) /* gives
221             ↪ better stability and better compression on sequent data and even on random
222             ↪ numbers data (but gives collisions anyway) */
223         {
224             _maxDoublet = doublet;
225             _maxDoubletData = data;
226         }
227     }
228 }

```

1.89 ./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     public abstract class LinksListToSequenceConverterBase<TLink> : LinksOperatorBase<TLink>,
10     ↪ IConverter<IList<TLink>, TLink>
11     {
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         protected LinksListToSequenceConverterBase(ILinks<TLink> links) : base(links) { }
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public abstract TLink Convert(IList<TLink> source);
17     }
18 }

```

1.90 ./csharp/Platform.Data.Doublets/Sequences/Converters/OptimalVariantConverter.cs

```

1 using System.Collections.Generic;
2 using System.Linq;
3 using System.Runtime.CompilerServices;
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     public class OptimalVariantConverter<TLink> : LinksListToSequenceConverterBase<TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15         ↪ EqualityComparer<TLink>.Default;
16         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
17
18         private readonly IConverter<IList<TLink>> _sequenceToItsLocalElementLevelsConverter;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public OptimalVariantConverter(ILinks<TLink> links, IConverter<IList<TLink>>
22         ↪ sequenceToItsLocalElementLevelsConverter) : base(links)

```

```

21     => _sequenceToItsLocalElementLevelsConverter =
22         ↳ sequenceToItsLocalElementLevelsConverter;
23
24 [MethodImpl(MethodImplOptions.AggressiveInlining)]
25 public OptimalVariantConverter(ILinks<TLink> links, LinkFrequenciesCache<TLink>
26     ↳ linkFrequenciesCache)
27     : this(links, new SequenceToItsLocalElementLevelsConverter<TLink>(links, new Frequen_
28         ↳ ciesCacheBasedLinkToItsFrequencyNumberConverter<TLink>(linkFrequenciesCache))) {
29     ↳ }
30
31 [MethodImpl(MethodImplOptions.AggressiveInlining)]
32 public OptimalVariantConverter(ILinks<TLink> links)
33     : this(links, new LinkFrequenciesCache<TLink>(links, new
34         ↳ TotalSequenceSymbolFrequencyCounter<TLink>(links))) { }
35
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 public override TLink Convert(ICollection<TLink> sequence)
38 {
39     var length = sequence.Count;
40     if (length == 1)
41     {
42         return sequence[0];
43     }
44     if (length == 2)
45     {
46         return _links.GetOrCreate(sequence[0], sequence[1]);
47     }
48     sequence = sequence.ToArray();
49     var levels = _sequenceToItsLocalElementLevelsConverter.Convert(sequence);
50     while (length > 2)
51     {
52         var levelRepeat = 1;
53         var currentLevel = levels[0];
54         var previousLevel = levels[0];
55         var skipOnce = false;
56         var w = 0;
57         for (var i = 1; i < length; i++)
58         {
59             if (_equalityComparer.Equals(currentLevel, levels[i]))
60             {
61                 levelRepeat++;
62                 skipOnce = false;
63                 if (levelRepeat == 2)
64                 {
65                     sequence[w] = _links.GetOrCreate(sequence[i - 1], sequence[i]);
66                     var newLevel = i >= length - 1 ?
67                         GetPreviousLowerThanCurrentOrCurrent(previousLevel,
68                             ↳ currentLevel) :
69                         i < 2 ?
70                         GetNextLowerThanCurrentOrCurrent(currentLevel, levels[i + 1]) :
71                         GetGreatestNeighbourLowerThanCurrentOrCurrent(previousLevel,
72                             ↳ currentLevel, levels[i + 1]);
73                     levels[w] = newLevel;
74                     previousLevel = currentLevel;
75                     w++;
76                     levelRepeat = 0;
77                     skipOnce = true;
78                 }
79                 else if (i == length - 1)
80                 {
81                     sequence[w] = sequence[i];
82                     levels[w] = levels[i];
83                     w++;
84                 }
85             }
86             else
87             {
88                 currentLevel = levels[i];
89                 levelRepeat = 1;
90                 if (skipOnce)
91                 {
92                     skipOnce = false;
93                 }
94                 else
95                 {
96                     sequence[w] = sequence[i - 1];
97                     levels[w] = levels[i - 1];
98                     previousLevel = levels[w];
99                     w++;
100                 }
101             }
102         }
103     }
104     return sequence[w];
105 }

```

```

93         }
94         if (i == length - 1)
95         {
96             sequence[w] = sequence[i];
97             levels[w] = levels[i];
98             w++;
99         }
100     }
101     }
102     length = w;
103 }
104 return _links.GetOrCreate(sequence[0], sequence[1]);
105 }
106
107 [MethodImpl(MethodImplOptions.AggressiveInlining)]
108 private static TLink GetGreatestNeighbourLowerThanCurrentOrCurrent(TLink previous, TLink
    ↪ current, TLink next)
109 {
110     return _comparer.Compare(previous, next) > 0
111         ? _comparer.Compare(previous, current) < 0 ? previous : current
112         : _comparer.Compare(next, current) < 0 ? next : current;
113 }
114
115 [MethodImpl(MethodImplOptions.AggressiveInlining)]
116 private static TLink GetNextLowerThanCurrentOrCurrent(TLink current, TLink next) =>
    ↪ _comparer.Compare(next, current) < 0 ? next : current;
117
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 private static TLink GetPreviousLowerThanCurrentOrCurrent(TLink previous, TLink current)
    ↪ => _comparer.Compare(previous, current) < 0 ? previous : current;
120 }
121 }

```

1.91 ./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     public class SequenceToItsLocalElementLevelsConverter<TLink> : LinksOperatorBase<TLink>,
    ↪ IConverter<IList<TLink>>
10     {
11         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
12
13         private readonly IConverter<Doublet<TLink>, TLink> _linkToItsFrequencyToNumberConveter;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public SequenceToItsLocalElementLevelsConverter(ILinks<TLink> links,
    ↪ IConverter<Doublet<TLink>, TLink> linkToItsFrequencyToNumberConveter) : base(links)
    ↪ => _linkToItsFrequencyToNumberConveter = linkToItsFrequencyToNumberConveter;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public IList<TLink> Convert(IList<TLink> sequence)
20         {
21             var levels = new TLink[sequence.Count];
22             levels[0] = GetFrequencyNumber(sequence[0], sequence[1]);
23             for (var i = 1; i < sequence.Count - 1; i++)
24             {
25                 var previous = GetFrequencyNumber(sequence[i - 1], sequence[i]);
26                 var next = GetFrequencyNumber(sequence[i], sequence[i + 1]);
27                 levels[i] = _comparer.Compare(previous, next) > 0 ? previous : next;
28             }
29             levels[levels.Length - 1] = GetFrequencyNumber(sequence[sequence.Count - 2],
    ↪ sequence[sequence.Count - 1]);
30             return levels;
31         }
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         public TLink GetFrequencyNumber(TLink source, TLink target) =>
    ↪ _linkToItsFrequencyToNumberConveter.Convert(new Doublet<TLink>(source, target));
35     }
36 }

```

1.92 ./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     public class DefaultSequenceElementCriterionMatcher<TLink> : LinksOperatorBase<TLink>,
9         ↳ ICriterionMatcher<TLink>
10    {
11        [MethodImpl(MethodImplOptions.AggressiveInlining)]
12        public DefaultSequenceElementCriterionMatcher(ILinks<TLink> links) : base(links) { }
13
14        [MethodImpl(MethodImplOptions.AggressiveInlining)]
15        public bool IsMatched(TLink argument) => _links.IsPartialPoint(argument);
16    }
17 }

```

1.93 ./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     public class MarkedSequenceCriterionMatcher<TLink> : ICriterionMatcher<TLink>
10    {
11        private static readonly EqualityComparer<TLink> _equalityComparer =
12            ↳ EqualityComparer<TLink>.Default;
13
14        private readonly ILinks<TLink> _links;
15        private readonly TLink _sequenceMarkerLink;
16
17        [MethodImpl(MethodImplOptions.AggressiveInlining)]
18        public MarkedSequenceCriterionMatcher(ILinks<TLink> links, TLink sequenceMarkerLink)
19        {
20            _links = links;
21            _sequenceMarkerLink = sequenceMarkerLink;
22        }
23
24        [MethodImpl(MethodImplOptions.AggressiveInlining)]
25        public bool IsMatched(TLink sequenceCandidate)
26            => _equalityComparer.Equals(_links.GetSource(sequenceCandidate), _sequenceMarkerLink)
27            || !_equalityComparer.Equals(_links.SearchOrDefault(_sequenceMarkerLink,
28                ↳ sequenceCandidate), _links.Constants.Null);
29    }
30 }

```

1.94 ./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     public class DefaultSequenceAppender<TLink> : LinksOperatorBase<TLink>,
12         ↳ ISequenceAppender<TLink>
13    {
14        private static readonly EqualityComparer<TLink> _equalityComparer =
15            ↳ EqualityComparer<TLink>.Default;
16
17        private readonly IStack<TLink> _stack;
18        private readonly ISequenceHeightProvider<TLink> _heightProvider;
19
20        [MethodImpl(MethodImplOptions.AggressiveInlining)]
21        public DefaultSequenceAppender(ILinks<TLink> links, IStack<TLink> stack,
22            ↳ ISequenceHeightProvider<TLink> heightProvider)
23            : base(links)
24        {
25            _stack = stack;
26            _heightProvider = heightProvider;
27        }
28
29        [MethodImpl(MethodImplOptions.AggressiveInlining)]
30        public TLink Append(TLink sequence, TLink appendant)
31        {
32
33        }
34    }
35 }

```

```

29     var cursor = sequence;
30     var links = _links;
31     while (!_equalityComparer.Equals(_heightProvider.Get(cursor), default))
32     {
33         var source = links.GetSource(cursor);
34         var target = links.GetTarget(cursor);
35         if (_equalityComparer.Equals(_heightProvider.Get(source),
36             ↪ _heightProvider.Get(target)))
37         {
38             break;
39         }
40         else
41         {
42             _stack.Push(source);
43             cursor = target;
44         }
45     }
46     var left = cursor;
47     var right = appendant;
48     while (!_equalityComparer.Equals(cursor = _stack.Pop(), links.Constants.Null))
49     {
50         right = links.GetOrCreate(left, right);
51         left = cursor;
52     }
53     return links.GetOrCreate(left, right);
54 }
55 }

```

1.95 ./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     public class DuplicateSegmentsCounter<TLink> : ICounter<int>
11     {
12         private readonly IProvider<IList<KeyValuePair<IList<TLink>, IList<TLink>>>>
13             ↪ _duplicateFragmentsProvider;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public DuplicateSegmentsCounter(IProvider<IList<KeyValuePair<IList<TLink>,
17             ↪ IList<TLink>>>> duplicateFragmentsProvider) => _duplicateFragmentsProvider =
18             ↪ duplicateFragmentsProvider;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public int Count() => _duplicateFragmentsProvider.Get().Sum(x => x.Value.Count);
22     }
23 }

```

1.96 ./csharp/Platform.Data.Doublets/Sequences/DuplicateSegmentsProvider.cs

```

1  using System;
2  using System.Linq;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Interfaces;
6  using Platform.Collections;
7  using Platform.Collections.Lists;
8  using Platform.Collections.Segments;
9  using Platform.Collections.Segments.Walkers;
10 using Platform.Singletons;
11 using Platform.Converters;
12 using Platform.Data.Doublets.Unicode;
13
14 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
15
16 namespace Platform.Data.Doublets.Sequences
17 {
18     public class DuplicateSegmentsProvider<TLink> :
19         ↪ DictionaryBasedDuplicateSegmentsWalkerBase<TLink>,
20         ↪ IProvider<IList<KeyValuePair<IList<TLink>, IList<TLink>>>>
21     {
22         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
23             ↪ UncheckedConverter<TLink, long>.Default;
24         private static readonly UncheckedConverter<TLink, ulong> _addressToUInt64Converter =
25             ↪ UncheckedConverter<TLink, ulong>.Default;
26     }
27 }

```

```

22 private static readonly UncheckedConverter<ulong, TLink> _uInt64ToAddressConverter =
    ↳ UncheckedConverter<ulong, TLink>.Default;
23
24 private readonly ILinks<TLink> _links;
25 private readonly ILinks<TLink> _sequences;
26 private HashSet<KeyValuePair<IList<TLink>, IList<TLink>>> _groups;
27 private BitString _visited;
28
29 private class ItemEquilityComparer : IEqualityComparer<KeyValuePair<IList<TLink>,
    ↳ IList<TLink>>>
30 {
31     private readonly IListEqualityComparer<TLink> _listComparer;
32
33     public ItemEquilityComparer() => _listComparer =
    ↳ Default<IListEqualityComparer<TLink>>.Instance;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     public bool Equals(KeyValuePair<IList<TLink>, IList<TLink>> left,
    ↳ KeyValuePair<IList<TLink>, IList<TLink>> right) =>
    ↳ _listComparer.Equals(left.Key, right.Key) && _listComparer.Equals(left.Value,
    ↳ right.Value);
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     public int GetHashCode(KeyValuePair<IList<TLink>, IList<TLink>> pair) =>
    ↳ (_listComparer.GetHashCode(pair.Key),
    ↳ _listComparer.GetHashCode(pair.Value)).GetHashCode();
40 }
41
42 private class ItemComparer : IComparer<KeyValuePair<IList<TLink>, IList<TLink>>>
43 {
44     private readonly IListComparer<TLink> _listComparer;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     public ItemComparer() => _listComparer = Default<IListComparer<TLink>>.Instance;
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     public int Compare(KeyValuePair<IList<TLink>, IList<TLink>> left,
    ↳ KeyValuePair<IList<TLink>, IList<TLink>> right)
51     {
52         var intermediateResult = _listComparer.Compare(left.Key, right.Key);
53         if (intermediateResult == 0)
54         {
55             intermediateResult = _listComparer.Compare(left.Value, right.Value);
56         }
57         return intermediateResult;
58     }
59 }
60
61 [MethodImpl(MethodImplOptions.AggressiveInlining)]
62 public DuplicateSegmentsProvider(ILinks<TLink> links, ILinks<TLink> sequences)
63     : base(minimumStringSegmentLength: 2)
64 {
65     _links = links;
66     _sequences = sequences;
67 }
68
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 public IList<KeyValuePair<IList<TLink>, IList<TLink>>> Get()
71 {
72     _groups = new HashSet<KeyValuePair<IList<TLink>,
    ↳ IList<TLink>>>(Default<ItemEquilityComparer>.Instance);
73     var links = _links;
74     var count = links.Count();
75     _visited = new BitString(_addressToInt64Converter.Convert(count) + 1L);
76     links.Each(link =>
77     {
78         var linkIndex = links.GetIndex(link);
79         var linkBitIndex = _addressToInt64Converter.Convert(linkIndex);
80         var constants = links.Constants;
81         if (!_visited.Get(linkBitIndex))
82         {
83             var sequenceElements = new List<TLink>();
84             var filler = new ListFiller<TLink, TLink>(sequenceElements, constants.Break);
85             _sequences.Each(filler.AddSkipFirstAndReturnConstant, new
    ↳ LinkAddress<TLink>(linkIndex));
86             if (sequenceElements.Count > 2)
87             {
88                 WalkAll(sequenceElements);
89             }

```



```

90     }
91     return constants.Continue;
92 });
93 var resultList = _groups.ToList();
94 var comparer = Default<ItemComparer>.Instance;
95 resultList.Sort(comparer);
96 #if DEBUG
97     foreach (var item in resultList)
98     {
99         PrintDuplicates(item);
100     }
101 #endif
102     return resultList;
103 }
104
105 [MethodImpl(MethodImplOptions.AggressiveInlining)]
106 protected override Segment<TLink> CreateSegment(IList<TLink> elements, int offset, int
    ↪ length) => new Segment<TLink>(elements, offset, length);
107
108 [MethodImpl(MethodImplOptions.AggressiveInlining)]
109 protected override void OnDuplicateFound(Segment<TLink> segment)
110 {
111     var duplicates = CollectDuplicatesForSegment(segment);
112     if (duplicates.Count > 1)
113     {
114         _groups.Add(new KeyValuePair<IList<TLink>, IList<TLink>>(segment.ToArray(),
            ↪ duplicates));
115     }
116 }
117
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 private List<TLink> CollectDuplicatesForSegment(Segment<TLink> segment)
120 {
121     var duplicates = new List<TLink>();
122     var readAsElement = new HashSet<TLink>();
123     var restrictions = segment.ShiftRight();
124     var constants = _links.Constants;
125     restrictions[0] = constants.Any;
126     _sequences.Each(sequence =>
127     {
128         var sequenceIndex = sequence[constants.IndexPart];
129         duplicates.Add(sequenceIndex);
130         readAsElement.Add(sequenceIndex);
131         return constants.Continue;
132     }, restrictions);
133     if (duplicates.Any(x => _visited.Get(_addressToInt64Converter.Convert(x))))
134     {
135         return new List<TLink>();
136     }
137     foreach (var duplicate in duplicates)
138     {
139         var duplicateBitIndex = _addressToInt64Converter.Convert(duplicate);
140         _visited.Set(duplicateBitIndex);
141     }
142     if (_sequences is Sequences sequencesExperiments)
143     {
144         var partiallyMatched = sequencesExperiments.GetAllPartiallyMatchingSequences4((H_
            ↪ ashSet<ulong>)(object)readAsElement,
            ↪ (IList<ulong>)segment);
145         foreach (var partiallyMatchedSequence in partiallyMatched)
146         {
147             var sequenceIndex =
            ↪ _uInt64ToAddressConverter.Convert(partiallyMatchedSequence);
148             duplicates.Add(sequenceIndex);
149         }
150     }
151     duplicates.Sort();
152     return duplicates;
153 }
154
155 [MethodImpl(MethodImplOptions.AggressiveInlining)]
156 private void PrintDuplicates(KeyValuePair<IList<TLink>, IList<TLink>> duplicatesItem)
157 {
158     if (!(_links is ILinks<ulong> ulongLinks))
159     {
160         return;
161     }
162     var duplicatesKey = duplicatesItem.Key;

```

```

163     var keyString = UnicodeMap.FromLinksToString((IList<ulong>)duplicatesKey);
164     Console.WriteLine($"{> {keyString} ({string.Join(", ", duplicatesKey)})");
165     var duplicatesList = duplicatesItem.Value;
166     for (int i = 0; i < duplicatesList.Count; i++)
167     {
168         var sequenceIndex = _addressToUInt64Converter.Convert(duplicatesList[i]);
169         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));
170         Console.WriteLine(formattedSequenceStructure);
171         var sequenceString = UnicodeMap.FromSequenceLinkToString(sequenceIndex,
            ↳ ulongLinks);
172         Console.WriteLine(sequenceString);
173     }
174     Console.WriteLine();
175 }
176 }
177 }

```

1.97 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Cache/LinkFrequenciesCache.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Interfaces;
5  using Platform.Numbers;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Sequences.Frequencies.Cache
10 {
11     /// <remarks>
12     /// Can be used to operate with many CompressingConverters (to keep global frequencies data
13     ↳ between them).
14     /// TODO: Extract interface to implement frequencies storage inside Links storage
15     /// </remarks>
16     public class LinkFrequenciesCache<TLink> : LinksOperatorBase<TLink>
17     {
18         private static readonly EqualityComparer<TLink> _equalityComparer =
19             ↳ EqualityComparer<TLink>.Default;
20         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
21
22         private static readonly TLink _zero = default;
23         private static readonly TLink _one = Arithmetic.Increment(_zero);
24
25         private readonly Dictionary<Doublet<TLink>, LinkFrequency<TLink>> _doubletsCache;
26         private readonly ICounter<TLink, TLink> _frequencyCounter;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public LinkFrequenciesCache(ILinks<TLink> links, ICounter<TLink, TLink> frequencyCounter)
30             : base(links)
31         {
32             _doubletsCache = new Dictionary<Doublet<TLink>, LinkFrequency<TLink>>(4096,
33                 ↳ DoubletComparer<TLink>.Default);
34             _frequencyCounter = frequencyCounter;
35         }
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public LinkFrequency<TLink> GetFrequency(TLink source, TLink target)
39         {
40             var doublet = new Doublet<TLink>(source, target);
41             return GetFrequency(ref doublet);
42         }
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         public LinkFrequency<TLink> GetFrequency(ref Doublet<TLink> doublet)
46         {
47             _doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data);
48             return data;
49         }
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         public void IncrementFrequencies(IList<TLink> sequence)
53         {
54             for (var i = 1; i < sequence.Count; i++)
55             {
56                 IncrementFrequency(sequence[i - 1], sequence[i]);
57             }
58         }
59     }
60 }

```

```

56 [MethodImpl(MethodImplOptions.AggressiveInlining)]
57 public LinkFrequency<TLink> IncrementFrequency(TLink source, TLink target)
58 {
59     var doublet = new Doublet<TLink>(source, target);
60     return IncrementFrequency(ref doublet);
61 }
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 public void PrintFrequencies(IList<TLink> sequence)
65 {
66     for (var i = 1; i < sequence.Count; i++)
67     {
68         PrintFrequency(sequence[i - 1], sequence[i]);
69     }
70 }
71
72 [MethodImpl(MethodImplOptions.AggressiveInlining)]
73 public void PrintFrequency(TLink source, TLink target)
74 {
75     var number = GetFrequency(source, target).Frequency;
76     Console.WriteLine("{0},{1} - {2}", source, target, number);
77 }
78
79 [MethodImpl(MethodImplOptions.AggressiveInlining)]
80 public LinkFrequency<TLink> IncrementFrequency(ref Doublet<TLink> doublet)
81 {
82     if (_doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data))
83     {
84         data.IncrementFrequency();
85     }
86     else
87     {
88         var link = _links.SearchOrDefault(doublet.Source, doublet.Target);
89         data = new LinkFrequency<TLink>(_one, link);
90         if (!_equalityComparer.Equals(link, default))
91         {
92             data.Frequency = Arithmetic.Add(data.Frequency,
93                 ↪ _frequencyCounter.Count(link));
94         }
95         _doubletsCache.Add(doublet, data);
96     }
97     return data;
98 }
99
100 [MethodImpl(MethodImplOptions.AggressiveInlining)]
101 public void ValidateFrequencies()
102 {
103     foreach (var entry in _doubletsCache)
104     {
105         var value = entry.Value;
106         var linkIndex = value.Link;
107         if (!_equalityComparer.Equals(linkIndex, default))
108         {
109             var frequency = value.Frequency;
110             var count = _frequencyCounter.Count(linkIndex);
111             // TODO0: Why `frequency` always greater than `count` by 1?
112             if (((_comparer.Compare(frequency, count) > 0) &&
113                 ↪ (_comparer.Compare(Arithmetic.Subtract(frequency, count), _one) > 0))
114                 || ((_comparer.Compare(count, frequency) > 0) &&
115                 ↪ (_comparer.Compare(Arithmetic.Subtract(count, frequency), _one) > 0)))
116             {
117                 throw new InvalidOperationException("Frequencies validation failed.");
118             }
119             //else
120             //{
121             //    if (value.Frequency > 0)
122             //    {
123             //        var frequency = value.Frequency;
124             //        linkIndex = _createLink(entry.Key.Source, entry.Key.Target);
125             //        var count = _countLinkFrequency(linkIndex);
126             //        if ((frequency > count && frequency - count > 1) || (count > frequency
127             //            ↪ && count - frequency > 1))
128             //            throw new InvalidOperationException("Frequencies validation
129             //            ↪ failed.");
130             //    }
131             //}

```

```

129         //}
130     }
131 }
132 }
133 }

```

1.98 ./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     public class LinkFrequency<TLink>
9     {
10         public TLink Frequency { get; set; }
11         public TLink Link { get; set; }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public LinkFrequency(TLink frequency, TLink link)
15         {
16             Frequency = frequency;
17             Link = link;
18         }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public LinkFrequency() { }
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public void IncrementFrequency() => Frequency = Arithmetic<TLink>.Increment(Frequency);
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public void DecrementFrequency() => Frequency = Arithmetic<TLink>.Decrement(Frequency);
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public override string ToString() => $"F: {Frequency}, L: {Link}";
31     }
32 }

```

1.99 ./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     public class FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<TLink> :
9         ⇨ IConverter<Doublet<TLink>, TLink>
10     {
11         private readonly LinkFrequenciesCache<TLink> _cache;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public
15         ⇨ FrequenciesCacheBasedLinkToItsFrequencyNumberConverter(LinkFrequenciesCache<TLink>
16         ⇨ cache) => _cache = cache;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public TLink Convert(Doublet<TLink> source) => _cache.GetFrequency(ref source).Frequency;
20     }
21 }

```

1.100 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/MarkedSequenceSymbolFrequencyOneOffCounter.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     public class MarkedSequenceSymbolFrequencyOneOffCounter<TLink> :
9         ⇨ SequenceSymbolFrequencyOneOffCounter<TLink>
10     {
11         private readonly ICriterionMatcher<TLink> _markedSequenceMatcher;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public MarkedSequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links,
15         ⇨ ICriterionMatcher<TLink> markedSequenceMatcher, TLink sequenceLink, TLink symbol)
16     {
17     }
18 }

```

```

14         : base(links, sequenceLink, symbol)
15         => _markedSequenceMatcher = markedSequenceMatcher;
16
17     [MethodImpl(MethodImplOptions.AggressiveInlining)]
18     public override TLink Count()
19     {
20         if (!_markedSequenceMatcher.IsMatched(_sequenceLink))
21         {
22             return default;
23         }
24         return base.Count();
25     }
26 }
27 }

```

1.101 ./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     public class SequenceSymbolFrequencyOneOffCounter<TLink> : ICounter<TLink>
12     {
13         private static readonly EqualityComparer<TLink> _equalityComparer =
14             ↳ EqualityComparer<TLink>.Default;
15         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
16
17         protected readonly ILinks<TLink> _links;
18         protected readonly TLink _sequenceLink;
19         protected readonly TLink _symbol;
20         protected TLink _total;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public SequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links, TLink sequenceLink,
24             ↳ TLink symbol)
25         {
26             _links = links;
27             _sequenceLink = sequenceLink;
28             _symbol = symbol;
29             _total = default;
30         }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public virtual TLink Count()
34         {
35             if (_comparer.Compare(_total, default) > 0)
36             {
37                 return _total;
38             }
39             StopableSequenceWalker.WalkRight(_sequenceLink, _links.GetSource, _links.GetTarget,
40                 ↳ IsElement, VisitElement);
41             return _total;
42         }
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         private bool IsElement(TLink x) => _equalityComparer.Equals(x, _symbol) ||
46             ↳ _links.IsPartialPoint(x); // TODO: Use SequenceElementCriteriaMatcher instead of
47             ↳ IsPartialPoint
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         private bool VisitElement(TLink element)
51         {
52             if (_equalityComparer.Equals(element, _symbol))
53             {
54                 _total = Arithmetic.Increment(_total);
55             }
56             return true;
57         }
58     }
59 }

```

1.102 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequency

```

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     public class TotalMarkedSequenceSymbolFrequencyCounter<TLink> : ICounter<TLink, TLink>
9     {
10         private readonly ILinks<TLink> _links;
11         private readonly ICriterionMatcher<TLink> _markedSequenceMatcher;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public TotalMarkedSequenceSymbolFrequencyCounter(ILinks<TLink> links,
15             ↪ ICriterionMatcher<TLink> markedSequenceMatcher)
16         {
17             _links = links;
18             _markedSequenceMatcher = markedSequenceMatcher;
19         }
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public TLink Count(TLink argument) => new
23             ↪ TotalMarkedSequenceSymbolFrequencyOneOffCounter<TLink>(_links,
24             ↪ _markedSequenceMatcher, argument).Count();
25     }
26 }

```

1.103 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequencyCounterOneOffCounter.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     public class TotalMarkedSequenceSymbolFrequencyOneOffCounter<TLink> :
10         ↪ TotalSequenceSymbolFrequencyOneOffCounter<TLink>
11     {
12         private readonly ICriterionMatcher<TLink> _markedSequenceMatcher;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public TotalMarkedSequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links,
16             ↪ ICriterionMatcher<TLink> markedSequenceMatcher, TLink symbol)
17             : base(links, symbol)
18             => _markedSequenceMatcher = markedSequenceMatcher;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override void CountSequenceSymbolFrequency(TLink link)
22         {
23             var symbolFrequencyCounter = new
24                 ↪ MarkedSequenceSymbolFrequencyOneOffCounter<TLink>(_links,
25                 ↪ _markedSequenceMatcher, link, _symbol);
26             _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
27         }
28     }
29 }

```

1.104 ./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     public class TotalSequenceSymbolFrequencyCounter<TLink> : ICounter<TLink, TLink>
9     {
10         private readonly ILinks<TLink> _links;
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public TotalSequenceSymbolFrequencyCounter(ILinks<TLink> links) => _links = links;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public TLink Count(TLink symbol) => new
17             ↪ TotalSequenceSymbolFrequencyOneOffCounter<TLink>(_links, symbol).Count();
18     }
19 }

```

1.105 ./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     public class TotalSequenceSymbolFrequencyOneOffCounter<TLink> : ICounter<TLink>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
13             ↪ EqualityComparer<TLink>.Default;
14         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
15
16         protected readonly ILinks<TLink> _links;
17         protected readonly TLink _symbol;
18         protected readonly HashSet<TLink> _visits;
19         protected TLink _total;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public TotalSequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links, TLink symbol)
23         {
24             _links = links;
25             _symbol = symbol;
26             _visits = new HashSet<TLink>();
27             _total = default;
28         }
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public TLink Count()
32         {
33             if (_comparer.Compare(_total, default) > 0 || _visits.Count > 0)
34             {
35                 return _total;
36             }
37             CountCore(_symbol);
38             return _total;
39         }
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         private void CountCore(TLink link)
43         {
44             var any = _links.Constants.Any;
45             if (_equalityComparer.Equals(_links.Count(any, link), default))
46             {
47                 CountSequenceSymbolFrequency(link);
48             }
49             else
50             {
51                 _links.Each(EachElementHandler, any, link);
52             }
53         }
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected virtual void CountSequenceSymbolFrequency(TLink link)
57         {
58             var symbolFrequencyCounter = new SequenceSymbolFrequencyOneOffCounter<TLink>(_links,
59                 ↪ link, _symbol);
60             _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
61         }
62
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         private TLink EachElementHandler(IList<TLink> doublet)
65         {
66             var constants = _links.Constants;
67             var doubletIndex = doublet[constants.IndexPart];
68             if (_visits.Add(doubletIndex))
69             {
70                 CountCore(doubletIndex);
71             }
72             return constants.Continue;
73         }
74     }
75 }

```

1.106 ./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     public class CachedSequenceHeightProvider<TLink> : ISequenceHeightProvider<TLink>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
13             ↳ EqualityComparer<TLink>.Default;
14
15         private readonly TLink _heightPropertyMarker;
16         private readonly ISequenceHeightProvider<TLink> _baseHeightProvider;
17         private readonly IConverter<TLink> _addressToUnaryNumberConverter;
18         private readonly IConverter<TLink> _unaryNumberToAddressConverter;
19         private readonly IProperties<TLink, TLink, TLink> _propertyOperator;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public CachedSequenceHeightProvider(
23             ISequenceHeightProvider<TLink> baseHeightProvider,
24             IConverter<TLink> addressToUnaryNumberConverter,
25             IConverter<TLink> unaryNumberToAddressConverter,
26             TLink heightPropertyMarker,
27             IProperties<TLink, TLink, TLink> propertyOperator)
28         {
29             _heightPropertyMarker = heightPropertyMarker;
30             _baseHeightProvider = baseHeightProvider;
31             _addressToUnaryNumberConverter = addressToUnaryNumberConverter;
32             _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
33             _propertyOperator = propertyOperator;
34         }
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public TLink Get(TLink sequence)
38         {
39             TLink height;
40             var heightValue = _propertyOperator.GetValue(sequence, _heightPropertyMarker);
41             if (_equalityComparer.Equals(heightValue, default))
42             {
43                 height = _baseHeightProvider.Get(sequence);
44                 heightValue = _addressToUnaryNumberConverter.Convert(height);
45                 _propertyOperator.SetValue(sequence, _heightPropertyMarker, heightValue);
46             }
47             else
48             {
49                 height = _unaryNumberToAddressConverter.Convert(heightValue);
50             }
51             return height;
52         }
53     }

```

1.107 ./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     public class DefaultSequenceRightHeightProvider<TLink> : LinksOperatorBase<TLink>,
10         ↳ ISequenceHeightProvider<TLink>
11     {
12         private readonly ICriterionMatcher<TLink> _elementMatcher;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public DefaultSequenceRightHeightProvider(ILinks<TLink> links, ICriterionMatcher<TLink>
16             ↳ elementMatcher) : base(links) => _elementMatcher = elementMatcher;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public TLink Get(TLink sequence)
20         {
21             var height = default(TLink);
22             var pairOrElement = sequence;
23             while (!_elementMatcher.IsMatched(pairOrElement))
24             {
25                 pairOrElement = _links.GetTarget(pairOrElement);
26                 height = Arithmetic.Increment(height);
27             }
28             return height;
29         }
30     }

```



```

28     }
29 }

```

1.108 ./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     public interface ISequenceHeightProvider<TLink> : IProvider<TLink, TLink>
8     {
9     }
10 }

```

1.109 ./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     public class CachedFrequencyIncrementingSequenceIndex<TLink> : ISequenceIndex<TLink>
10    {
11        private static readonly EqualityComparer<TLink> _equalityComparer =
12            ↪ EqualityComparer<TLink>.Default;
13
14        private readonly LinkFrequenciesCache<TLink> _cache;
15
16        [MethodImpl(MethodImplOptions.AggressiveInlining)]
17        public CachedFrequencyIncrementingSequenceIndex(LinkFrequenciesCache<TLink> cache) =>
18            ↪ _cache = cache;
19
20        [MethodImpl(MethodImplOptions.AggressiveInlining)]
21        public bool Add(IList<TLink> sequence)
22        {
23            var indexed = true;
24            var i = sequence.Count;
25            while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
26                ↪ { }
27            for (; i >= 1; i--)
28            {
29                _cache.IncrementFrequency(sequence[i - 1], sequence[i]);
30            }
31            return indexed;
32        }
33
34        [MethodImpl(MethodImplOptions.AggressiveInlining)]
35        private bool IsIndexedWithIncrement(TLink source, TLink target)
36        {
37            var frequency = _cache.GetFrequency(source, target);
38            if (frequency == null)
39            {
40                return false;
41            }
42            var indexed = !_equalityComparer.Equals(frequency.Frequency, default);
43            if (indexed)
44            {
45                _cache.IncrementFrequency(source, target);
46            }
47            return indexed;
48        }
49
50        [MethodImpl(MethodImplOptions.AggressiveInlining)]
51        public bool MightContain(IList<TLink> sequence)
52        {
53            var indexed = true;
54            var i = sequence.Count;
55            while (--i >= 1 && (indexed = IsIndexed(sequence[i - 1], sequence[i]))) { }
56            return indexed;
57        }
58
59        [MethodImpl(MethodImplOptions.AggressiveInlining)]
60        private bool IsIndexed(TLink source, TLink target)
61        {
62            var frequency = _cache.GetFrequency(source, target);
63            if (frequency == null)
64            {

```

```

62         return false;
63     }
64     return !_equalityComparer.Equals(frequency.Frequency, default);
65 }
66 }
67 }

```

1.110 ./csharp/Platform.Data.Doublets/Sequences/Indexes/FrequencyIncrementingSequenceIndex.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Incrementers;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Sequences.Indexes
9  {
10     public class FrequencyIncrementingSequenceIndex<TLink> : SequenceIndex<TLink>,
11         ↳ ISequenceIndex<TLink>
12     {
13         private static readonly EqualityComparer<TLink> _equalityComparer =
14             ↳ EqualityComparer<TLink>.Default;
15
16         private readonly IProperty<TLink, TLink> _frequencyPropertyOperator;
17         private readonly IIncrementer<TLink> _frequencyIncrementer;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public FrequencyIncrementingSequenceIndex(ILinks<TLink> links, IProperty<TLink, TLink>
21             ↳ frequencyPropertyOperator, IIncrementer<TLink> frequencyIncrementer)
22             : base(links)
23         {
24             _frequencyPropertyOperator = frequencyPropertyOperator;
25             _frequencyIncrementer = frequencyIncrementer;
26         }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public override bool Add(IList<TLink> sequence)
30         {
31             var indexed = true;
32             var i = sequence.Count;
33             while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
34                 ↳ { }
35             for (; i >= 1; i--)
36             {
37                 Increment(_links.GetOrCreate(sequence[i - 1], sequence[i]));
38             }
39             return indexed;
40         }
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         private bool IsIndexedWithIncrement(TLink source, TLink target)
44         {
45             var link = _links.SearchOrDefault(source, target);
46             var indexed = !_equalityComparer.Equals(link, default);
47             if (indexed)
48             {
49                 Increment(link);
50             }
51             return indexed;
52         }
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         private void Increment(TLink link)
56         {
57             var previousFrequency = _frequencyPropertyOperator.Get(link);
58             var frequency = _frequencyIncrementer.Increment(previousFrequency);
59             _frequencyPropertyOperator.Set(link, frequency);
60         }
61     }
62 }

```

1.111 ./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     public interface ISequenceIndex<TLink>
9     {
10         /// <summary>
11         /// Индексирует последовательность глобально, и возвращает значение,
12         /// определяющие была ли запрошенная последовательность проиндексирована ранее.
13         /// </summary>
14         /// <param name="sequence">Последовательность для индексации.</param>
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         bool Add(IList<TLink> sequence);
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         bool MightContain(IList<TLink> sequence);
20     }
21 }

```

1.112 ./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      public class SequenceIndex<TLink> : LinksOperatorBase<TLink>, ISequenceIndex<TLink>
9      {
10         private static readonly EqualityComparer<TLink> _equalityComparer =
11             ⇨ EqualityComparer<TLink>.Default;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public SequenceIndex(ILinks<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public virtual bool Add(IList<TLink> sequence)
18         {
19             var indexed = true;
20             var i = sequence.Count;
21             while (--i >= 1 && (indexed =
22                 ⇨ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
23                 ⇨ default))) { }
24             for (; i >= 1; i--)
25             {
26                 _links.GetOrCreate(sequence[i - 1], sequence[i]);
27             }
28             return indexed;
29         }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public virtual bool MightContain(IList<TLink> sequence)
33         {
34             var indexed = true;
35             var i = sequence.Count;
36             while (--i >= 1 && (indexed =
37                 ⇨ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
38                 ⇨ default))) { }
39             return indexed;
40         }
41     }
42 }

```

1.113 ./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      public class SynchronizedSequenceIndex<TLink> : ISequenceIndex<TLink>
9      {
10         private static readonly EqualityComparer<TLink> _equalityComparer =
11             ⇨ EqualityComparer<TLink>.Default;
12
13         private readonly ISynchronizedLinks<TLink> _links;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public SynchronizedSequenceIndex(ISynchronizedLinks<TLink> links) => _links = links;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public bool Add(IList<TLink> sequence)

```

```

19     {
20         var indexed = true;
21         var i = sequence.Count;
22         var links = _links.Unsync;
23         _links.SyncRoot.ExecuteReadOperation(() =>
24         {
25             while (--i >= 1 && (indexed =
26                 ↪ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
27                 ↪ sequence[i]), default))) { }
28         });
29         if (!indexed)
30         {
31             _links.SyncRoot.ExecuteWriteOperation(() =>
32             {
33                 for (; i >= 1; i--)
34                 {
35                     links.GetOrCreate(sequence[i - 1], sequence[i]);
36                 }
37             });
38             return indexed;
39         }
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         public bool MightContain(ICollection<TLink> sequence)
42         {
43             var links = _links.Unsync;
44             return _links.SyncRoot.ExecuteReadOperation(() =>
45             {
46                 var indexed = true;
47                 var i = sequence.Count;
48                 while (--i >= 1 && (indexed =
49                     ↪ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
50                     ↪ sequence[i]), default))) { }
51                 return indexed;
52             });
53         }
54     }
55 }

```

1.114 ./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      public class Unindex<TLink> : ISequenceIndex<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public virtual bool Add(ICollection<TLink> sequence) => false;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public virtual bool MightContain(ICollection<TLink> sequence) => true;
15     }
16 }

```

1.115 ./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     partial class Sequences
21     {

```

```

22 #region Create All Variants (Not Practical)
23
24 /// <remarks>
25 /// Number of links that is needed to generate all variants for
26 /// sequence of length N corresponds to https://oeis.org/A014143/list sequence.
27 /// </remarks>
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 public ulong[] CreateAllVariants2(ulong[] sequence)
30 {
31     return _sync.ExecuteWriteOperation(() =>
32     {
33         if (sequence.IsNullOrEmpty())
34         {
35             return Array.Empty<ulong>();
36         }
37         Links.EnsureLinkExists(sequence);
38         if (sequence.Length == 1)
39         {
40             return sequence;
41         }
42         return CreateAllVariants2Core(sequence, 0, sequence.Length - 1);
43     });
44 }
45
46 [MethodImpl(MethodImplOptions.AggressiveInlining)]
47 private ulong[] CreateAllVariants2Core(ulong[] sequence, long startAt, long stopAt)
48 {
49     #if DEBUG
50         if ((stopAt - startAt) < 0)
51         {
52             throw new ArgumentOutOfRangeException(nameof(startAt), "startAt должен быть
53                 ↳ меньше или равен stopAt");
54         }
55         #endif
56         if ((stopAt - startAt) == 0)
57         {
58             return new[] { sequence[startAt] };
59         }
60         if ((stopAt - startAt) == 1)
61         {
62             return new[] { Links.Unsync.GetOrCreate(sequence[startAt], sequence[stopAt]) };
63         }
64         var variants = new ulong[(ulong)Platform.Numbers.Math.Catalan(stopAt - startAt)];
65         var last = 0;
66         for (var splitter = startAt; splitter < stopAt; splitter++)
67         {
68             var left = CreateAllVariants2Core(sequence, startAt, splitter);
69             var right = CreateAllVariants2Core(sequence, splitter + 1, stopAt);
70             for (var i = 0; i < left.Length; i++)
71             {
72                 for (var j = 0; j < right.Length; j++)
73                 {
74                     var variant = Links.Unsync.GetOrCreate(left[i], right[j]);
75                     if (variant == Constants.Null)
76                     {
77                         throw new NotImplementedException("Creation cancellation is not
78                             ↳ implemented.");
79                     }
80                     variants[last++] = variant;
81                 }
82             }
83         }
84         return variants;
85     }
86 }
87
88 [MethodImpl(MethodImplOptions.AggressiveInlining)]
89 public List<ulong> CreateAllVariants1(params ulong[] sequence)
90 {
91     return _sync.ExecuteWriteOperation(() =>
92     {
93         if (sequence.IsNullOrEmpty())
94         {
95             return new List<ulong>();
96         }
97         Links.Unsync.EnsureLinkExists(sequence);
98         if (sequence.Length == 1)
99         {
100             return new List<ulong> { sequence[0] };
101         }
102     });
103 }

```

```

98     }
99     var results = new
    ↳ List<ulong>((int)Platform.Numbers.Math.Catalan(sequence.Length));
100     return CreateAllVariants1Core(sequence, results);
101 });
102 }
103
104 [MethodImpl(MethodImplOptions.AggressiveInlining)]
105 private List<ulong> CreateAllVariants1Core(ulong[] sequence, List<ulong> results)
106 {
107     if (sequence.Length == 2)
108     {
109         var link = Links.Unsync.GetOrCreate(sequence[0], sequence[1]);
110         if (link == Constants.Null)
111         {
112             throw new NotImplementedException("Creation cancellation is not
    ↳ implemented.");
113         }
114         results.Add(link);
115         return results;
116     }
117     var innerSequenceLength = sequence.Length - 1;
118     var innerSequence = new ulong[innerSequenceLength];
119     for (var li = 0; li < innerSequenceLength; li++)
120     {
121         var link = Links.Unsync.GetOrCreate(sequence[li], sequence[li + 1]);
122         if (link == Constants.Null)
123         {
124             throw new NotImplementedException("Creation cancellation is not
    ↳ implemented.");
125         }
126         for (var isi = 0; isi < li; isi++)
127         {
128             innerSequence[isi] = sequence[isi];
129         }
130         innerSequence[li] = link;
131         for (var isi = li + 1; isi < innerSequenceLength; isi++)
132         {
133             innerSequence[isi] = sequence[isi + 1];
134         }
135         CreateAllVariants1Core(innerSequence, results);
136     }
137     return results;
138 }
139
140 #endregion
141
142 [MethodImpl(MethodImplOptions.AggressiveInlining)]
143 public HashSet<ulong> Each1(params ulong[] sequence)
144 {
145     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
146     Each1(link =>
147     {
148         if (!visitedLinks.Contains(link))
149         {
150             visitedLinks.Add(link); // изучить почему случаются повторы
151         }
152         return true;
153     }, sequence);
154     return visitedLinks;
155 }
156
157 [MethodImpl(MethodImplOptions.AggressiveInlining)]
158 private void Each1(Func<ulong, bool> handler, params ulong[] sequence)
159 {
160     if (sequence.Length == 2)
161     {
162         Links.Unsync.Each(sequence[0], sequence[1], handler);
163     }
164     else
165     {
166         var innerSequenceLength = sequence.Length - 1;
167         for (var li = 0; li < innerSequenceLength; li++)
168         {
169             var left = sequence[li];
170             var right = sequence[li + 1];
171             if (left == 0 && right == 0)
172             {

```

```

173         continue;
174     }
175     var linkIndex = li;
176     ulong[] innerSequence = null;
177     Links.Unsync.Each(doublet =>
178     {
179         if (innerSequence == null)
180         {
181             innerSequence = new ulong[innerSequenceLength];
182             for (var isi = 0; isi < linkIndex; isi++)
183             {
184                 innerSequence[isi] = sequence[isi];
185             }
186             for (var isi = linkIndex + 1; isi < innerSequenceLength; isi++)
187             {
188                 innerSequence[isi] = sequence[isi + 1];
189             }
190         }
191         innerSequence[linkIndex] = doublet[Constants.IndexPart];
192         Each1(handler, innerSequence);
193         return Constants.Continue;
194     }, Constants.Any, left, right);
195 }
196 }
197 }
198
199 [MethodImpl(MethodImplOptions.AggressiveInlining)]
200 public HashSet<ulong> EachPart(params ulong[] sequence)
201 {
202     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
203     EachPartCore(link =>
204     {
205         var linkIndex = link[Constants.IndexPart];
206         if (!visitedLinks.Contains(linkIndex))
207         {
208             visitedLinks.Add(linkIndex); // изучить почему случаются повторы
209         }
210         return Constants.Continue;
211     }, sequence);
212     return visitedLinks;
213 }
214
215 [MethodImpl(MethodImplOptions.AggressiveInlining)]
216 public void EachPart(Func<IList<LinkIndex>, LinkIndex> handler, params ulong[] sequence)
217 {
218     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
219     EachPartCore(link =>
220     {
221         var linkIndex = link[Constants.IndexPart];
222         if (!visitedLinks.Contains(linkIndex))
223         {
224             visitedLinks.Add(linkIndex); // изучить почему случаются повторы
225             return handler(new LinkAddress<LinkIndex>(linkIndex));
226         }
227         return Constants.Continue;
228     }, sequence);
229 }
230
231 [MethodImpl(MethodImplOptions.AggressiveInlining)]
232 private void EachPartCore(Func<IList<LinkIndex>, LinkIndex> handler, params ulong[]
233 ↪ sequence)
234 {
235     if (sequence.IsNullOrEmpty())
236     {
237         return;
238     }
239     Links.EnsureLinkIsAnyOrExists(sequence);
240     if (sequence.Length == 1)
241     {
242         var link = sequence[0];
243         if (link > 0)
244         {
245             handler(new LinkAddress<LinkIndex>(link));
246         }
247         else
248         {
249             Links.Each(Constants.Any, Constants.Any, handler);
250         }
251     }
252 }

```

```

250     }
251     else if (sequence.Length == 2)
252     {
253         //_links.Each(sequence[0], sequence[1], handler);
254         //  o_|      x_o ...
255         // x_|      |__|
256         Links.Each(sequence[1], Constants.Any, doublet =>
257         {
258             var match = Links.SearchOrDefault(sequence[0], doublet);
259             if (match != Constants.Null)
260             {
261                 handler(new LinkAddress<LinkIndex>(match));
262             }
263             return true;
264         });
265         // |_x      ... x_o
266         // |_o      |__|
267         Links.Each(Constants.Any, sequence[0], doublet =>
268         {
269             var match = Links.SearchOrDefault(doublet, sequence[1]);
270             if (match != 0)
271             {
272                 handler(new LinkAddress<LinkIndex>(match));
273             }
274             return true;
275         });
276         //      .x o_.
277         //      |__|
278         PartialStepRight(x => handler(x), sequence[0], sequence[1]);
279     }
280     else
281     {
282         throw new NotImplementedException();
283     }
284 }
285
286 [MethodImpl(MethodImplOptions.AggressiveInlining)]
287 private void PartialStepRight(Action<IList<LinkIndex>> handler, ulong left, ulong right)
288 {
289     Links.Unsync.Each(Constants.Any, left, doublet =>
290     {
291         StepRight(handler, doublet, right);
292         if (left != doublet)
293         {
294             PartialStepRight(handler, doublet, right);
295         }
296         return true;
297     });
298 }
299
300 [MethodImpl(MethodImplOptions.AggressiveInlining)]
301 private void StepRight(Action<IList<LinkIndex>> handler, ulong left, ulong right)
302 {
303     Links.Unsync.Each(left, Constants.Any, rightStep =>
304     {
305         TryStepRightUp(handler, right, rightStep);
306         return true;
307     });
308 }
309
310 [MethodImpl(MethodImplOptions.AggressiveInlining)]
311 private void TryStepRightUp(Action<IList<LinkIndex>> handler, ulong right, ulong
↪ stepFrom)
312 {
313     var upStep = stepFrom;
314     var firstSource = Links.Unsync.GetTarget(upStep);
315     while (firstSource != right && firstSource != upStep)
316     {
317         upStep = firstSource;
318         firstSource = Links.Unsync.GetSource(upStep);
319     }
320     if (firstSource == right)
321     {
322         handler(new LinkAddress<LinkIndex>(stepFrom));
323     }
324 }
325
326 // TODO: Test

```



```

327 [MethodImpl(MethodImplOptions.AggressiveInlining)]
328 private void PartialStepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
329 {
330     Links.Unsync.Each(right, Constants.Any, doublet =>
331     {
332         StepLeft(handler, left, doublet);
333         if (right != doublet)
334         {
335             PartialStepLeft(handler, left, doublet);
336         }
337         return true;
338     });
339 }
340
341 [MethodImpl(MethodImplOptions.AggressiveInlining)]
342 private void StepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
343 {
344     Links.Unsync.Each(Constants.Any, right, leftStep =>
345     {
346         TryStepLeftUp(handler, left, leftStep);
347         return true;
348     });
349 }
350
351 [MethodImpl(MethodImplOptions.AggressiveInlining)]
352 private void TryStepLeftUp(Action<IList<LinkIndex>> handler, ulong left, ulong stepFrom)
353 {
354     var upStep = stepFrom;
355     var firstTarget = Links.Unsync.GetSource(upStep);
356     while (firstTarget != left && firstTarget != upStep)
357     {
358         upStep = firstTarget;
359         firstTarget = Links.Unsync.GetTarget(upStep);
360     }
361     if (firstTarget == left)
362     {
363         handler(new LinkAddress<LinkIndex>(stepFrom));
364     }
365 }
366
367 [MethodImpl(MethodImplOptions.AggressiveInlining)]
368 private bool StartsWith(ulong sequence, ulong link)
369 {
370     var upStep = sequence;
371     var firstSource = Links.Unsync.GetSource(upStep);
372     while (firstSource != link && firstSource != upStep)
373     {
374         upStep = firstSource;
375         firstSource = Links.Unsync.GetSource(upStep);
376     }
377     return firstSource == link;
378 }
379
380 [MethodImpl(MethodImplOptions.AggressiveInlining)]
381 private bool EndsWith(ulong sequence, ulong link)
382 {
383     var upStep = sequence;
384     var lastTarget = Links.Unsync.GetTarget(upStep);
385     while (lastTarget != link && lastTarget != upStep)
386     {
387         upStep = lastTarget;
388         lastTarget = Links.Unsync.GetTarget(upStep);
389     }
390     return lastTarget == link;
391 }
392
393 [MethodImpl(MethodImplOptions.AggressiveInlining)]
394 public List<ulong> GetAllMatchingSequences0(params ulong[] sequence)
395 {
396     return _sync.ExecuteReadOperation(() =>
397     {
398         var results = new List<ulong>();
399         if (sequence.Length > 0)
400         {
401             Links.EnsureLinkExists(sequence);
402             var firstElement = sequence[0];
403             if (sequence.Length == 1)
404             {
405                 results.Add(firstElement);

```

```

406         return results;
407     }
408     if (sequence.Length == 2)
409     {
410         var doublet = Links.SearchOrDefault(firstElement, sequence[1]);
411         if (doublet != Constants.Null)
412         {
413             results.Add(doublet);
414         }
415         return results;
416     }
417     var linksInSequence = new HashSet<ulong>(sequence);
418     void handler(ICollection<LinkIndex> result)
419     {
420         var resultIndex = result[Links.Constants.IndexPart];
421         var filterPosition = 0;
422         StopableSequenceWalker.WalkRight(resultIndex, Links.Unsync.GetSource,
423             ↪ Links.Unsync.GetTarget,
424             ↪ x => linksInSequence.Contains(x) || Links.Unsync.GetTarget(x) == x,
425             ↪ x =>
426             {
427                 if (filterPosition == sequence.Length)
428                 {
429                     filterPosition = -2; // Длиннее чем нужно
430                     return false;
431                 }
432                 if (x != sequence[filterPosition])
433                 {
434                     filterPosition = -1;
435                     return false; // Начинается иначе
436                 }
437                 filterPosition++;
438                 return true;
439             });
440         if (filterPosition == sequence.Length)
441         {
442             results.Add(resultIndex);
443         }
444     }
445     if (sequence.Length >= 2)
446     {
447         StepRight(handler, sequence[0], sequence[1]);
448     }
449     var last = sequence.Length - 2;
450     for (var i = 1; i < last; i++)
451     {
452         PartialStepRight(handler, sequence[i], sequence[i + 1]);
453     }
454     if (sequence.Length >= 3)
455     {
456         StepLeft(handler, sequence[sequence.Length - 2],
457             ↪ sequence[sequence.Length - 1]);
458     }
459 }
460
461     });
462     return results;
463 }
464
465 [MethodImpl(MethodImplOptions.AggressiveInlining)]
466 public HashSet<ulong> GetAllMatchingSequences1(params ulong[] sequence)
467 {
468     return _sync.ExecuteReadOperation(() =>
469     {
470         var results = new HashSet<ulong>();
471         if (sequence.Length > 0)
472         {
473             Links.EnsureLinkExists(sequence);
474             var firstElement = sequence[0];
475             if (sequence.Length == 1)
476             {
477                 results.Add(firstElement);
478                 return results;
479             }
480             if (sequence.Length == 2)
481             {
482                 var doublet = Links.SearchOrDefault(firstElement, sequence[1]);
483                 if (doublet != Constants.Null)

```

```

481         {
482             results.Add(doublet);
483         }
484         return results;
485     }
486     var matcher = new Matcher(this, sequence, results, null);
487     if (sequence.Length >= 2)
488     {
489         StepRight(matcher.AddFullMatchedToResults, sequence[0], sequence[1]);
490     }
491     var last = sequence.Length - 2;
492     for (var i = 1; i < last; i++)
493     {
494         PartialStepRight(matcher.AddFullMatchedToResults, sequence[i],
495             ↪ sequence[i + 1]);
496     }
497     if (sequence.Length >= 3)
498     {
499         StepLeft(matcher.AddFullMatchedToResults, sequence[sequence.Length - 2],
500             ↪ sequence[sequence.Length - 1]);
501     }
502     return results;
503 });
504 }
505
506 public const int MaxSequenceFormatSize = 200;
507
508 [MethodImpl(MethodImplOptions.AggressiveInlining)]
509 public string FormatSequence(LinkIndex sequenceLink, params LinkIndex[] knownElements)
510     ↪ => FormatSequence(sequenceLink, (sb, x) => sb.Append(x), true, knownElements);
511
512 [MethodImpl(MethodImplOptions.AggressiveInlining)]
513 public string FormatSequence(LinkIndex sequenceLink, Action<StringBuilder, LinkIndex>
514     ↪ elementToString, bool insertComma, params LinkIndex[] knownElements) =>
515     ↪ Links.SyncRoot.ExecuteReadOperation(() => FormatSequence(Links.Unsync, sequenceLink,
516     ↪ elementToString, insertComma, knownElements));
517
518 [MethodImpl(MethodImplOptions.AggressiveInlining)]
519 private string FormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
520     ↪ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
521     ↪ LinkIndex[] knownElements)
522 {
523     var linksInSequence = new HashSet<ulong>(knownElements);
524     //var entered = new HashSet<ulong>();
525     var sb = new StringBuilder();
526     sb.Append('{');
527     if (links.Exists(sequenceLink))
528     {
529         StopableSequenceWalker.WalkRight(sequenceLink, links.GetSource, links.GetTarget,
530             x => linksInSequence.Contains(x) || links.IsPartialPoint(x), element => //
531             ↪ entered.AddAndReturnVoid, x => { }, entered.DoNotContains
532         {
533             if (insertComma && sb.Length > 1)
534             {
535                 sb.Append(',');
536             }
537             //if (entered.Contains(element))
538             //{
539             //    sb.Append('{');
540             //    elementToString(sb, element);
541             //    sb.Append('}');
542             //}
543             //else
544             elementToString(sb, element);
545             if (sb.Length < MaxSequenceFormatSize)
546             {
547                 return true;
548             }
549             sb.Append(insertComma ? ", ..." : "...");
550             return false;
551         }
552     }
553     sb.Append('}');
554     return sb.ToString();
555 }
556
557 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

550 public string SafeFormatSequence(LinkIndex sequenceLink, params LinkIndex[]
    ↪ knownElements) => SafeFormatSequence(sequenceLink, (sb, x) => sb.Append(x), true,
    ↪ knownElements);

551
552 [MethodImpl(MethodImplOptions.AggressiveInlining)]
553 public string SafeFormatSequence(LinkIndex sequenceLink, Action<StringBuilder,
    ↪ LinkIndex> elementToString, bool insertComma, params LinkIndex[] knownElements) =>
    ↪ Links.SyncRoot.ExecuteReadOperation(() => SafeFormatSequence(Links.Unsync,
    ↪ sequenceLink, elementToString, insertComma, knownElements));

554
555 [MethodImpl(MethodImplOptions.AggressiveInlining)]
556 private string SafeFormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
    ↪ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
    ↪ LinkIndex[] knownElements)
557 {
558     var linksInSequence = new HashSet<ulong>(knownElements);
559     var entered = new HashSet<ulong>();
560     var sb = new StringBuilder();
561     sb.Append('{');
562     if (links.Exists(sequenceLink))
563     {
564         StopableSequenceWalker.WalkRight(sequenceLink, links.GetSource, links.GetTarget,
565             x => linksInSequence.Contains(x) || links.IsFullPoint(x),
566             ↪ entered.AddAndReturnVoid, x => { }, entered.DoNotContains, element =>
567             {
568                 if (insertComma && sb.Length > 1)
569                 {
570                     sb.Append(',');
571                 }
572                 if (entered.Contains(element))
573                 {
574                     sb.Append('{');
575                     elementToString(sb, element);
576                     sb.Append('}');
577                 }
578                 else
579                 {
580                     elementToString(sb, element);
581                 }
582                 if (sb.Length < MaxSequenceFormatSize)
583                 {
584                     return true;
585                 }
586                 sb.Append(insertComma ? ", ..." : "...");
587                 return false;
588             });
589     }
590     sb.Append('}');
591     return sb.ToString();
592 }

593 [MethodImpl(MethodImplOptions.AggressiveInlining)]
594 public List<ulong> GetAllPartiallyMatchingSequences0(params ulong[] sequence)
595 {
596     return _sync.ExecuteReadOperation(() =>
597     {
598         if (sequence.Length > 0)
599         {
600             Links.EnsureLinkExists(sequence);
601             var results = new HashSet<ulong>();
602             for (var i = 0; i < sequence.Length; i++)
603             {
604                 AllUsagesCore(sequence[i], results);
605             }
606             var filteredResults = new List<ulong>();
607             var linksInSequence = new HashSet<ulong>(sequence);
608             foreach (var result in results)
609             {
610                 var filterPosition = -1;
611                 StopableSequenceWalker.WalkRight(result, Links.Unsync.GetSource,
612                     ↪ Links.Unsync.GetTarget,
613                     x => linksInSequence.Contains(x) || Links.Unsync.GetTarget(x) == x,
614                     ↪ x =>
615                     {
616                         if (filterPosition == (sequence.Length - 1))
617                         {
618                             return false;
619                         }
620                     }

```

```

618         if (filterPosition >= 0)
619         {
620             if (x == sequence[filterPosition + 1])
621             {
622                 filterPosition++;
623             }
624             else
625             {
626                 return false;
627             }
628         }
629         if (filterPosition < 0)
630         {
631             if (x == sequence[0])
632             {
633                 filterPosition = 0;
634             }
635         }
636         return true;
637     });
638     if (filterPosition == (sequence.Length - 1))
639     {
640         filteredResults.Add(result);
641     }
642 }
643 return filteredResults;
644 }
645 return new List<ulong>();
646 });
647 }
648
649 [MethodImpl(MethodImplOptions.AggressiveInlining)]
650 public HashSet<ulong> GetAllPartiallyMatchingSequences1(params ulong[] sequence)
651 {
652     return _sync.ExecuteReadOperation(() =>
653     {
654         if (sequence.Length > 0)
655         {
656             Links.EnsureLinkExists(sequence);
657             var results = new HashSet<ulong>();
658             for (var i = 0; i < sequence.Length; i++)
659             {
660                 AllUsagesCore(sequence[i], results);
661             }
662             var filteredResults = new HashSet<ulong>();
663             var matcher = new Matcher(this, sequence, filteredResults, null);
664             matcher.AddAllPartialMatchedToResults(results);
665             return filteredResults;
666         }
667         return new HashSet<ulong>();
668     });
669 }
670
671 [MethodImpl(MethodImplOptions.AggressiveInlining)]
672 public bool GetAllPartiallyMatchingSequences2(Func<IList<LinkIndex>, LinkIndex> handler,
673     ↪ params ulong[] sequence)
674 {
675     return _sync.ExecuteReadOperation(() =>
676     {
677         if (sequence.Length > 0)
678         {
679             Links.EnsureLinkExists(sequence);
680
681             var results = new HashSet<ulong>();
682             var filteredResults = new HashSet<ulong>();
683             var matcher = new Matcher(this, sequence, filteredResults, handler);
684             for (var i = 0; i < sequence.Length; i++)
685             {
686                 if (!AllUsagesCore1(sequence[i], results, matcher.HandlePartialMatched))
687                 {
688                     return false;
689                 }
690             }
691             return true;
692         }
693         return true;
694     });
695 }

```

```

696 //public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
697 //{
698 //    return Sync.ExecuteReadOperation(() =>
699 //    {
700 //        if (sequence.Length > 0)
701 //        {
702 //            _links.EnsureEachLinkIsAnyOrExists(sequence);
703
704 //            var firstResults = new HashSet<ulong>();
705 //            var lastResults = new HashSet<ulong>();
706
707 //            var first = sequence.First(x => x != LinksConstants.Any);
708 //            var last = sequence.Last(x => x != LinksConstants.Any);
709
710 //            AllUsagesCore(first, firstResults);
711 //            AllUsagesCore(last, lastResults);
712
713 //            firstResults.IntersectWith(lastResults);
714
715 //            //for (var i = 0; i < sequence.Length; i++)
716 //            //    AllUsagesCore(sequence[i], results);
717
718 //            var filteredResults = new HashSet<ulong>();
719 //            var matcher = new Matcher(this, sequence, filteredResults, null);
720 //            matcher.AddAllPartialMatchedToResults(firstResults);
721 //            return filteredResults;
722 //        }
723
724 //        return new HashSet<ulong>();
725 //    });
726 //}
727
728 [MethodImpl(MethodImplOptions.AggressiveInlining)]
729 public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
730 {
731     return _sync.ExecuteReadOperation((Func<HashSet<ulong>>)(() =>
732     {
733         if (sequence.Length > 0)
734         {
735             ILinksExtensions.EnsureLinkIsAnyOrExists<ulong>(Links,
736                 ↪ (IList<ulong>)sequence);
737             var firstResults = new HashSet<ulong>();
738             var lastResults = new HashSet<ulong>();
739             var first = sequence.First(x => x != Constants.Any);
740             var last = sequence.Last(x => x != Constants.Any);
741             AllUsagesCore(first, firstResults);
742             AllUsagesCore(last, lastResults);
743             firstResults.IntersectWith(lastResults);
744             //for (var i = 0; i < sequence.Length; i++)
745             //    AllUsagesCore(sequence[i], results);
746             var filteredResults = new HashSet<ulong>();
747             var matcher = new Matcher(this, sequence, filteredResults, null);
748             matcher.AddAllPartialMatchedToResults(firstResults);
749             return filteredResults;
750         }
751         return new HashSet<ulong>();
752     }));
753 }
754
755 [MethodImpl(MethodImplOptions.AggressiveInlining)]
756 public HashSet<ulong> GetAllPartiallyMatchingSequences4(HashSet<ulong> readAsElements,
757     ↪ IList<ulong> sequence)
758 {
759     return _sync.ExecuteReadOperation(() =>
760     {
761         if (sequence.Count > 0)
762         {
763             Links.EnsureLinkExists(sequence);
764             var results = new HashSet<LinkIndex>();
765             //var nextResults = new HashSet<ulong>();
766             //for (var i = 0; i < sequence.Length; i++)
767             //{
768             //    AllUsagesCore(sequence[i], nextResults);
769             //    if (results.IsNullOrEmpty())
770             //    {
771                 results = nextResults;
772                 nextResults = new HashSet<ulong>();
773             }
774         }
775     });
776 }

```

```

772         //     else
773         //     {
774         //         results.IntersectWith(nextResults);
775         //         nextResults.Clear();
776         //     }
777         //}
778         var collector1 = new AllUsagesCollector1(Links.Unsync, results);
779         collector1.Collect(Links.Unsync.GetLink(sequence[0]));
780         var next = new HashSet<ulong>();
781         for (var i = 1; i < sequence.Count; i++)
782         {
783             var collector = new AllUsagesCollector1(Links.Unsync, next);
784             collector.Collect(Links.Unsync.GetLink(sequence[i]));
785
786             results.IntersectWith(next);
787             next.Clear();
788         }
789         var filteredResults = new HashSet<ulong>();
790         var matcher = new Matcher(this, sequence, filteredResults, null,
791             ↪ readAsElements);
792         matcher.AddAllPartialMatchedToResultsAndReadAsElements(results.OrderBy(x =>
793             ↪ x)); // OrderBy is a Hack
794         return filteredResults;
795     }
796     return new HashSet<ulong>();
797 });
798 }
799
800 // Does not work
801 //public HashSet<ulong> GetAllPartiallyMatchingSequences5(HashSet<ulong> readAsElements,
802 //    ↪ params ulong[] sequence)
803 //{
804 //    var visited = new HashSet<ulong>();
805 //    var results = new HashSet<ulong>();
806 //    var matcher = new Matcher(this, sequence, visited, x => { results.Add(x); return
807 //    ↪ true; }, readAsElements);
808 //    var last = sequence.Length - 1;
809 //    for (var i = 0; i < last; i++)
810 //    {
811 //        PartialStepRight(matcher.PartialMatch, sequence[i], sequence[i + 1]);
812 //    }
813 //    return results;
814 //}
815
816 [MethodImpl(MethodImplOptions.AggressiveInlining)]
817 public List<ulong> GetAllPartiallyMatchingSequences(params ulong[] sequence)
818 {
819     return _sync.ExecuteReadOperation(() =>
820     {
821         if (sequence.Length > 0)
822         {
823             Links.EnsureLinkExists(sequence);
824             //var firstElement = sequence[0];
825             //if (sequence.Length == 1)
826             //{
827             //    //results.Add(firstElement);
828             //    return results;
829             //}
830             //if (sequence.Length == 2)
831             //{
832             //    //var doublet = _links.SearchCore(firstElement, sequence[1]);
833             //    //if (doublet != Doublets.Links.Null)
834             //    //    results.Add(doublet);
835             //    return results;
836             //}
837             //var lastElement = sequence[sequence.Length - 1];
838             //Func<ulong, bool> handler = x =>
839             //{
840             //    if (StartsWith(x, firstElement) && EndsWith(x, lastElement))
841             //    ↪ results.Add(x);
842             //    return true;
843             //};
844             //if (sequence.Length >= 2)
845             //    StepRight(handler, sequence[0], sequence[1]);
846             //var last = sequence.Length - 2;
847             //for (var i = 1; i < last; i++)
848             //    PartialStepRight(handler, sequence[i], sequence[i + 1]);

```

```

844 //if (sequence.Length >= 3)
845 //    StepLeft(handler, sequence[sequence.Length - 2],
846 //        sequence[sequence.Length - 1]);
847 //if (sequence.Length == 1)
848 //if (sequence.Length == 1)
849 //    throw new NotImplementedException(); // all sequences, containing
850 //    this element?
851 //if (sequence.Length == 2)
852 //if (sequence.Length == 2)
853 //    var results = new List<ulong>();
854 //    PartialStepRight(results.Add, sequence[0], sequence[1]);
855 //    return results;
856 //var matches = new List<List<ulong>>();
857 //var last = sequence.Length - 1;
858 //for (var i = 0; i < last; i++)
859 //if (sequence.Length == 2)
860 //    var results = new List<ulong>();
861 //    //StepRight(results.Add, sequence[i], sequence[i + 1]);
862 //    PartialStepRight(results.Add, sequence[i], sequence[i + 1]);
863 //    if (results.Count > 0)
864 //        matches.Add(results);
865 //    else
866 //        return results;
867 //    if (matches.Count == 2)
868 //    {
869 //        var merged = new List<ulong>();
870 //        for (var j = 0; j < matches[0].Count; j++)
871 //            for (var k = 0; k < matches[1].Count; k++)
872 //                CloseInnerConnections(merged.Add, matches[0][j],
873 //                    matches[1][k]);
874 //        if (merged.Count > 0)
875 //            matches = new List<List<ulong>> { merged };
876 //        else
877 //            return new List<ulong>();
878 //    }
879 //if (matches.Count > 0)
880 //if (matches.Count > 0)
881 //    var usages = new HashSet<ulong>();
882 //    for (int i = 0; i < sequence.Length; i++)
883 //    {
884 //        AllUsagesCore(sequence[i], usages);
885 //    }
886 //for (int i = 0; i < matches[0].Count; i++)
887 //    AllUsagesCore(matches[0][i], usages);
888 //usages.UnionWith(matches[0]);
889 //return usages.ToList();
890 //var firstLinkUsages = new HashSet<ulong>();
891 //AllUsagesCore(sequence[0], firstLinkUsages);
892 //firstLinkUsages.Add(sequence[0]);
893 //var previousMatchings = firstLinkUsages.ToList(); //new List<ulong>() {
894 //    sequence[0] }; // or all sequences, containing this element?
895 //return GetAllPartiallyMatchingSequencesCore(sequence, firstLinkUsages,
896 //    1).ToList();
897 //var results = new HashSet<ulong>();
898 //foreach (var match in GetAllPartiallyMatchingSequencesCore(sequence,
899 //    firstLinkUsages, 1))
900 //    AllUsagesCore(match, results);
901 //return results.ToList();
902 }
903 return new List<ulong>();
904 });
905 }
906
907 /// <remarks>
908 /// TODO: Может потребоваться ограничение на уровень глубины рекурсии
909 /// </remarks>
910 [MethodImpl(MethodImplOptions.AggressiveInlining)]
911 public HashSet<ulong> AllUsages(ulong link)
912 {
913     return _sync.ExecuteReadOperation(() =>
914     {

```



```

915         var usages = new HashSet<ulong>();
916         AllUsagesCore(link, usages);
917         return usages;
918     });
919 }
920
921 // При сборе всех использований (последовательностей) можно сохранять обратный путь к
922 //   ↳ той связи с которой начинался поиск (STTTSSSTT),
923 // причём достаточно одного бита для хранения перехода влево или вправо
924 [MethodImpl(MethodImplOptions.AggressiveInlining)]
925 private void AllUsagesCore(ulong link, HashSet<ulong> usages)
926 {
927     bool handler(ulong doublet)
928     {
929         if (usages.Add(doublet))
930         {
931             AllUsagesCore(doublet, usages);
932         }
933         return true;
934     }
935     Links.Unsync.Each(link, Constants.Any, handler);
936     Links.Unsync.Each(Constants.Any, link, handler);
937 }
938
939 [MethodImpl(MethodImplOptions.AggressiveInlining)]
940 public HashSet<ulong> AllBottomUsages(ulong link)
941 {
942     return _sync.ExecuteReadOperation(() =>
943     {
944         var visits = new HashSet<ulong>();
945         var usages = new HashSet<ulong>();
946         AllBottomUsagesCore(link, visits, usages);
947         return usages;
948     });
949 }
950
951 [MethodImpl(MethodImplOptions.AggressiveInlining)]
952 private void AllBottomUsagesCore(ulong link, HashSet<ulong> visits, HashSet<ulong>
953   ↳ usages)
954 {
955     bool handler(ulong doublet)
956     {
957         if (visits.Add(doublet))
958         {
959             AllBottomUsagesCore(doublet, visits, usages);
960         }
961         return true;
962     }
963     if (Links.Unsync.Count(Constants.Any, link) == 0)
964     {
965         usages.Add(link);
966     }
967     else
968     {
969         Links.Unsync.Each(link, Constants.Any, handler);
970         Links.Unsync.Each(Constants.Any, link, handler);
971     }
972 }
973
974 [MethodImpl(MethodImplOptions.AggressiveInlining)]
975 public ulong CalculateTotalSymbolFrequencyCore(ulong symbol)
976 {
977     if (Options.UseSequenceMarker)
978     {
979         var counter = new TotalMarkedSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
980   ↳ Options.MarkedSequenceMatcher, symbol);
981         return counter.Count();
982     }
983     else
984     {
985         var counter = new TotalSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
986   ↳ symbol);
987         return counter.Count();
988     }
989 }
990
991 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

988 private bool AllUsagesCore1(ulong link, HashSet<ulong> usages, Func<IList<LinkIndex>,
    ↳ LinkIndex> outerHandler)
989 {
990     bool handler(ulong doublet)
991     {
992         if (usages.Add(doublet))
993         {
994             if (outerHandler(new LinkAddress<LinkIndex>(doublet)) != Constants.Continue)
995             {
996                 return false;
997             }
998             if (!AllUsagesCore1(doublet, usages, outerHandler))
999             {
1000                 return false;
1001             }
1002         }
1003         return true;
1004     }
1005     return Links.Unsync.Each(link, Constants.Any, handler)
1006         && Links.Unsync.Each(Constants.Any, link, handler);
1007 }
1008
1009 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1010 public void CalculateAllUsages(ulong[] totals)
1011 {
1012     var calculator = new AllUsagesCalculator(Links, totals);
1013     calculator.Calculate();
1014 }
1015
1016 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1017 public void CalculateAllUsages2(ulong[] totals)
1018 {
1019     var calculator = new AllUsagesCalculator2(Links, totals);
1020     calculator.Calculate();
1021 }
1022
1023 private class AllUsagesCalculator
1024 {
1025     private readonly SynchronizedLinks<ulong> _links;
1026     private readonly ulong[] _totals;
1027
1028     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1029     public AllUsagesCalculator(SynchronizedLinks<ulong> links, ulong[] totals)
1030     {
1031         _links = links;
1032         _totals = totals;
1033     }
1034
1035     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1036     public void Calculate() => _links.Each(_links.Constants.Any, _links.Constants.Any,
    ↳ CalculateCore);
1037
1038     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1039     private bool CalculateCore(ulong link)
1040     {
1041         if (_totals[link] == 0)
1042         {
1043             var total = 1UL;
1044             _totals[link] = total;
1045             var visitedChildren = new HashSet<ulong>();
1046             bool linkCalculator(ulong child)
1047             {
1048                 if (link != child && visitedChildren.Add(child))
1049                 {
1050                     total += _totals[child] == 0 ? 1 : _totals[child];
1051                 }
1052                 return true;
1053             }
1054             _links.Unsync.Each(link, _links.Constants.Any, linkCalculator);
1055             _links.Unsync.Each(_links.Constants.Any, link, linkCalculator);
1056             _totals[link] = total;
1057         }
1058         return true;
1059     }
1060 }
1061
1062 private class AllUsagesCalculator2
1063 {
1064     private readonly SynchronizedLinks<ulong> _links;

```

```

1065 private readonly ulong[] _totals;
1066
1067 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1068 public AllUsagesCalculator2(SynchronizedLinks<ulong> links, ulong[] totals)
1069 {
1070     _links = links;
1071     _totals = totals;
1072 }
1073
1074 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1075 public void Calculate() => _links.Each(_links.Constants.Any, _links.Constants.Any,
    ↪ CalculateCore);
1076
1077 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1078 private bool IsElement(ulong link)
1079 {
1080     // _linksInSequence.Contains(link) ||
1081     return _links.Unsync.GetTarget(link) == link || _links.Unsync.GetSource(link) ==
    ↪ link;
1082 }
1083
1084 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1085 private bool CalculateCore(ulong link)
1086 {
1087     // TODO: Проработать защиту от заикливания
1088     // Основано на SequenceWalker.WalkLeft
1089     Func<ulong, ulong> getSource = _links.Unsync.GetSource;
1090     Func<ulong, ulong> getTarget = _links.Unsync.GetTarget;
1091     Func<ulong, bool> isElement = IsElement;
1092     void visitLeaf(ulong parent)
1093     {
1094         if (link != parent)
1095         {
1096             _totals[parent]++;
1097         }
1098     }
1099     void visitNode(ulong parent)
1100     {
1101         if (link != parent)
1102         {
1103             _totals[parent]++;
1104         }
1105     }
1106     var stack = new Stack();
1107     var element = link;
1108     if (isElement(element))
1109     {
1110         visitLeaf(element);
1111     }
1112     else
1113     {
1114         while (true)
1115         {
1116             if (isElement(element))
1117             {
1118                 if (stack.Count == 0)
1119                 {
1120                     break;
1121                 }
1122                 element = stack.Pop();
1123                 var source = getSource(element);
1124                 var target = getTarget(element);
1125                 // Обработка элемента
1126                 if (isElement(target))
1127                 {
1128                     visitLeaf(target);
1129                 }
1130                 if (isElement(source))
1131                 {
1132                     visitLeaf(source);
1133                 }
1134                 element = source;
1135             }
1136             else
1137             {
1138                 stack.Push(element);
1139                 visitNode(element);
1140                 element = getTarget(element);
1141             }
1142         }
1143     }
1144 }

```

```

1142     }
1143 }
1144     _totals[link]++;
1145     return true;
1146 }
1147 }
1148
1149 private class AllUsagesCollector
1150 {
1151     private readonly ILinks<ulong> _links;
1152     private readonly HashSet<ulong> _usages;
1153
1154     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1155     public AllUsagesCollector(ILinks<ulong> links, HashSet<ulong> usages)
1156     {
1157         _links = links;
1158         _usages = usages;
1159     }
1160
1161     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1162     public bool Collect(ulong link)
1163     {
1164         if (_usages.Add(link))
1165         {
1166             _links.Each(link, _links.Constants.Any, Collect);
1167             _links.Each(_links.Constants.Any, link, Collect);
1168         }
1169         return true;
1170     }
1171 }
1172
1173 private class AllUsagesCollector1
1174 {
1175     private readonly ILinks<ulong> _links;
1176     private readonly HashSet<ulong> _usages;
1177     private readonly ulong _continue;
1178
1179     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1180     public AllUsagesCollector1(ILinks<ulong> links, HashSet<ulong> usages)
1181     {
1182         _links = links;
1183         _usages = usages;
1184         _continue = _links.Constants.Continue;
1185     }
1186
1187     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1188     public ulong Collect(ICollection<ulong> link)
1189     {
1190         var linkIndex = _links.GetIndex(link);
1191         if (_usages.Add(linkIndex))
1192         {
1193             _links.Each(Collect, _links.Constants.Any, linkIndex);
1194         }
1195         return _continue;
1196     }
1197 }
1198
1199 private class AllUsagesCollector2
1200 {
1201     private readonly ILinks<ulong> _links;
1202     private readonly BitString _usages;
1203
1204     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1205     public AllUsagesCollector2(ILinks<ulong> links, BitString usages)
1206     {
1207         _links = links;
1208         _usages = usages;
1209     }
1210
1211     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1212     public bool Collect(ulong link)
1213     {
1214         if (_usages.Add((long)link))
1215         {
1216             _links.Each(link, _links.Constants.Any, Collect);
1217             _links.Each(_links.Constants.Any, link, Collect);
1218         }
1219         return true;
1220     }
1221 }

```

```

1222 private class AllUsagesIntersectingCollector
1223 {
1224     private readonly SynchronizedLinks<ulong> _links;
1225     private readonly HashSet<ulong> _intersectWith;
1226     private readonly HashSet<ulong> _usages;
1227     private readonly HashSet<ulong> _enter;
1228
1229     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1230     public AllUsagesIntersectingCollector(SynchronizedLinks<ulong> links, HashSet<ulong>
1231     ↪ intersectWith, HashSet<ulong> usages)
1232     {
1233         _links = links;
1234         _intersectWith = intersectWith;
1235         _usages = usages;
1236         _enter = new HashSet<ulong>(); // защита от зацикливания
1237     }
1238
1239     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1240     public bool Collect(ulong link)
1241     {
1242         if (_enter.Add(link))
1243         {
1244             if (_intersectWith.Contains(link))
1245             {
1246                 _usages.Add(link);
1247             }
1248             _links.Unsync.Each(link, _links.Constants.Any, Collect);
1249             _links.Unsync.Each(_links.Constants.Any, link, Collect);
1250         }
1251         return true;
1252     }
1253 }
1254
1255 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1256 private void CloseInnerConnections(Action<IList<LinkIndex>> handler, ulong left, ulong
1257 ↪ right)
1258 {
1259     TryStepLeftUp(handler, left, right);
1260     TryStepRightUp(handler, right, left);
1261 }
1262
1263 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1264 private void AllCloseConnections(Action<IList<LinkIndex>> handler, ulong left, ulong
1265 ↪ right)
1266 {
1267     // Direct
1268     if (left == right)
1269     {
1270         handler(new LinkAddress<LinkIndex>(left));
1271     }
1272     var doublet = Links.Unsync.SearchOrDefault(left, right);
1273     if (doublet != Constants.Null)
1274     {
1275         handler(new LinkAddress<LinkIndex>(doublet));
1276     }
1277     // Inner
1278     CloseInnerConnections(handler, left, right);
1279     // Outer
1280     StepLeft(handler, left, right);
1281     StepRight(handler, left, right);
1282     PartialStepRight(handler, left, right);
1283     PartialStepLeft(handler, left, right);
1284 }
1285
1286 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1287 private HashSet<ulong> GetAllPartiallyMatchingSequencesCore(ulong[] sequence,
1288 ↪ HashSet<ulong> previousMatchings, long startAt)
1289 {
1290     if (startAt >= sequence.Length) // ?
1291     {
1292         return previousMatchings;
1293     }
1294     var secondLinkUsages = new HashSet<ulong>();
1295     AllUsagesCore(sequence[startAt], secondLinkUsages);
1296     secondLinkUsages.Add(sequence[startAt]);
1297     var matchings = new HashSet<ulong>();
1298     var filler = new SetFiller<LinkIndex, LinkIndex>(matchings, Constants.Continue);

```

```

1296 //for (var i = 0; i < previousMatchings.Count; i++)
1297 foreach (var secondLinkUsage in secondLinkUsages)
1298 {
1299     foreach (var previousMatching in previousMatchings)
1300     {
1301         //AllCloseConnections(matchings.AddAndReturnVoid, previousMatching,
1302         ↪ secondLinkUsage);
1303         StepRight(filler.AddFirstAndReturnConstant, previousMatching,
1304         ↪ secondLinkUsage);
1305         TryStepRightUp(filler.AddFirstAndReturnConstant, secondLinkUsage,
1306         ↪ previousMatching);
1307         //PartialStepRight(matchings.AddAndReturnVoid, secondLinkUsage,
1308         ↪ sequence[startAt]); // почему-то эта ошибочная запись приводит к
1309         ↪ желаемым результатам.
1310         PartialStepRight(filler.AddFirstAndReturnConstant, previousMatching,
1311         ↪ secondLinkUsage);
1312     }
1313 }
1314 if (matchings.Count == 0)
1315 {
1316     return matchings;
1317 }
1318 return GetAllPartiallyMatchingSequencesCore(sequence, matchings, startAt + 1); // ??
1319 }
1320
1321 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1322 private static void EnsureEachLinkIsAnyOrZeroOrManyOrExists(SynchronizedLinks<ulong>
1323 ↪ links, params ulong[] sequence)
1324 {
1325     if (sequence == null)
1326     {
1327         return;
1328     }
1329     for (var i = 0; i < sequence.Length; i++)
1330     {
1331         if (sequence[i] != links.Constants.Any && sequence[i] != ZeroOrMany &&
1332         ↪ !links.Exists(sequence[i]))
1333         {
1334             throw new ArgumentLinkDoesNotExistsException<ulong>(sequence[i],
1335             ↪ $"patternSequence[{i}]");
1336         }
1337     }
1338 }
1339 }
1340
1341 // Pattern Matching -> Key To Triggers
1342 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1343 public HashSet<ulong> MatchPattern(params ulong[] patternSequence)
1344 {
1345     return _sync.ExecuteReadOperation(() =>
1346     {
1347         patternSequence = Simplify(patternSequence);
1348         if (patternSequence.Length > 0)
1349         {
1350             EnsureEachLinkIsAnyOrZeroOrManyOrExists(Links, patternSequence);
1351             var uniqueSequenceElements = new HashSet<ulong>();
1352             for (var i = 0; i < patternSequence.Length; i++)
1353             {
1354                 if (patternSequence[i] != Constants.Any && patternSequence[i] !=
1355                 ↪ ZeroOrMany)
1356                 {
1357                     uniqueSequenceElements.Add(patternSequence[i]);
1358                 }
1359             }
1360             var results = new HashSet<ulong>();
1361             foreach (var uniqueSequenceElement in uniqueSequenceElements)
1362             {
1363                 AllUsagesCore(uniqueSequenceElement, results);
1364             }
1365             var filteredResults = new HashSet<ulong>();
1366             var matcher = new PatternMatcher(this, patternSequence, filteredResults);
1367             matcher.AddAllPatternMatchedToResults(results);
1368             return filteredResults;
1369         }
1370         return new HashSet<ulong>();
1371     });
1372 }

```

```

1363 // Найти все возможные связи между указанным списком связей.
1364 // Находит связи между всеми указанными связями в любом порядке.
1365 // TODO: решить что делать с повторами (когда одни и те же элементы встречаются
    ↳ несколько раз в последовательности)
1366 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1367 public HashSet<ulong> GetAllConnections(params ulong[] linksToConnect)
1368 {
1369     return _sync.ExecuteReadOperation(() =>
1370     {
1371         var results = new HashSet<ulong>();
1372         if (linksToConnect.Length > 0)
1373         {
1374             Links.EnsureLinkExists(linksToConnect);
1375             AllUsagesCore(linksToConnect[0], results);
1376             for (var i = 1; i < linksToConnect.Length; i++)
1377             {
1378                 var next = new HashSet<ulong>();
1379                 AllUsagesCore(linksToConnect[i], next);
1380                 results.IntersectWith(next);
1381             }
1382         }
1383         return results;
1384     });
1385 }
1386
1387 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1388 public HashSet<ulong> GetAllConnections1(params ulong[] linksToConnect)
1389 {
1390     return _sync.ExecuteReadOperation(() =>
1391     {
1392         var results = new HashSet<ulong>();
1393         if (linksToConnect.Length > 0)
1394         {
1395             Links.EnsureLinkExists(linksToConnect);
1396             var collector1 = new AllUsagesCollector(Links.Unsync, results);
1397             collector1.Collect(linksToConnect[0]);
1398             var next = new HashSet<ulong>();
1399             for (var i = 1; i < linksToConnect.Length; i++)
1400             {
1401                 var collector = new AllUsagesCollector(Links.Unsync, next);
1402                 collector.Collect(linksToConnect[i]);
1403                 results.IntersectWith(next);
1404                 next.Clear();
1405             }
1406         }
1407         return results;
1408     });
1409 }
1410
1411 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1412 public HashSet<ulong> GetAllConnections2(params ulong[] linksToConnect)
1413 {
1414     return _sync.ExecuteReadOperation(() =>
1415     {
1416         var results = new HashSet<ulong>();
1417         if (linksToConnect.Length > 0)
1418         {
1419             Links.EnsureLinkExists(linksToConnect);
1420             var collector1 = new AllUsagesCollector(Links, results);
1421             collector1.Collect(linksToConnect[0]);
1422             //AllUsagesCore(linksToConnect[0], results);
1423             for (var i = 1; i < linksToConnect.Length; i++)
1424             {
1425                 var next = new HashSet<ulong>();
1426                 var collector = new AllUsagesIntersectingCollector(Links, results, next);
1427                 collector.Collect(linksToConnect[i]);
1428                 //AllUsagesCore(linksToConnect[i], next);
1429                 //results.IntersectWith(next);
1430                 results = next;
1431             }
1432         }
1433         return results;
1434     });
1435 }
1436
1437 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1438 public List<ulong> GetAllConnections3(params ulong[] linksToConnect)
1439 {

```

```

1440     return _sync.ExecuteReadOperation(()=>
1441     {
1442         var results = new BitString((long)Links.Unsync.Count() + 1); // new
1443         ↪ BitArray((int)_links.Total + 1);
1444         if (linksToConnect.Length > 0)
1445         {
1446             Links.EnsureLinkExists(linksToConnect);
1447             var collector1 = new AllUsagesCollector2(Links.Unsync, results);
1448             collector1.Collect(linksToConnect[0]);
1449             for (var i = 1; i < linksToConnect.Length; i++)
1450             {
1451                 var next = new BitString((long)Links.Unsync.Count() + 1); //new
1452                 ↪ BitArray((int)_links.Total + 1);
1453                 var collector = new AllUsagesCollector2(Links.Unsync, next);
1454                 collector.Collect(linksToConnect[i]);
1455                 results = results.And(next);
1456             }
1457             return results.GetSetUInt64Indices();
1458         });
1459     }
1460     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1461     private static ulong[] Simplify(ulong[] sequence)
1462     {
1463         // Считаем новый размер последовательности
1464         long newLength = 0;
1465         var zeroOrManyStepped = false;
1466         for (var i = 0; i < sequence.Length; i++)
1467         {
1468             if (sequence[i] == ZeroOrMany)
1469             {
1470                 if (zeroOrManyStepped)
1471                 {
1472                     continue;
1473                 }
1474                 zeroOrManyStepped = true;
1475             }
1476             else
1477             {
1478                 //if (zeroOrManyStepped) Is it efficient?
1479                 zeroOrManyStepped = false;
1480             }
1481             newLength++;
1482         }
1483         // Строим новую последовательность
1484         zeroOrManyStepped = false;
1485         var newSequence = new ulong[newLength];
1486         long j = 0;
1487         for (var i = 0; i < sequence.Length; i++)
1488         {
1489             //var current = zeroOrManyStepped;
1490             //zeroOrManyStepped = patternSequence[i] == zeroOrMany;
1491             //if (current && zeroOrManyStepped)
1492             //    continue;
1493             //var newZeroOrManyStepped = patternSequence[i] == zeroOrMany;
1494             //if (zeroOrManyStepped && newZeroOrManyStepped)
1495             //    continue;
1496             //zeroOrManyStepped = newZeroOrManyStepped;
1497             if (sequence[i] == ZeroOrMany)
1498             {
1499                 if (zeroOrManyStepped)
1500                 {
1501                     continue;
1502                 }
1503                 zeroOrManyStepped = true;
1504             }
1505             else
1506             {
1507                 //if (zeroOrManyStepped) Is it efficient?
1508                 zeroOrManyStepped = false;
1509             }
1510             newSequence[j++] = sequence[i];
1511         }
1512         return newSequence;
1513     }
1514
1515     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1516     public static void TestSimplify()

```



```

1517 {
1518     var sequence = new ulong[] { ZeroOrMany, ZeroOrMany, 2, 3, 4, ZeroOrMany,
1519         ↪ ZeroOrMany, ZeroOrMany, 4, ZeroOrMany, ZeroOrMany, ZeroOrMany };
1520     var simplifiedSequence = Simplify(sequence);
1521 }
1522 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1523 public List<ulong> GetSimilarSequences() => new List<ulong>();
1524
1525 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1526 public void Prediction()
1527 {
1528     //_links
1529     //_sequences
1530 }
1531
1532 #region From Triplets
1533
1534 //public static void DeleteSequence(Link sequence)
1535 //{
1536 //}
1537
1538 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1539 public List<ulong> CollectMatchingSequences(ulong[] links)
1540 {
1541     if (links.Length == 1)
1542     {
1543         throw new InvalidOperationException("Подпоследовательности с одним элементом не
1544             ↪ поддерживаются.");
1545     }
1546     var leftBound = 0;
1547     var rightBound = links.Length - 1;
1548     var left = links[leftBound++];
1549     var right = links[rightBound--];
1550     var results = new List<ulong>();
1551     CollectMatchingSequences(left, leftBound, links, right, rightBound, ref results);
1552     return results;
1553 }
1554
1555 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1556 private void CollectMatchingSequences(ulong leftLink, int leftBound, ulong[]
1557     ↪ middleLinks, ulong rightLink, int rightBound, ref List<ulong> results)
1558 {
1559     var leftLinkTotalReferers = Links.Unsync.Count(leftLink);
1560     var rightLinkTotalReferers = Links.Unsync.Count(rightLink);
1561     if (leftLinkTotalReferers <= rightLinkTotalReferers)
1562     {
1563         var nextLeftLink = middleLinks[leftBound];
1564         var elements = GetRightElements(leftLink, nextLeftLink);
1565         if (leftBound <= rightBound)
1566         {
1567             for (var i = elements.Length - 1; i >= 0; i--)
1568             {
1569                 var element = elements[i];
1570                 if (element != 0)
1571                 {
1572                     CollectMatchingSequences(element, leftBound + 1, middleLinks,
1573                         ↪ rightLink, rightBound, ref results);
1574                 }
1575             }
1576         }
1577         else
1578         {
1579             for (var i = elements.Length - 1; i >= 0; i--)
1580             {
1581                 var element = elements[i];
1582                 if (element != 0)
1583                 {
1584                     results.Add(element);
1585                 }
1586             }
1587         }
1588     }
1589     else
1590     {
1591         var nextRightLink = middleLinks[rightBound];
1592         var elements = GetLeftElements(rightLink, nextRightLink);
1593         if (leftBound <= rightBound)

```

```

1591     {
1592         for (var i = elements.Length - 1; i >= 0; i--)
1593         {
1594             var element = elements[i];
1595             if (element != 0)
1596             {
1597                 CollectMatchingSequences(leftLink, leftBound, middleLinks,
1598                     ↪ elements[i], rightBound - 1, ref results);
1599             }
1600         }
1601     }
1602     else
1603     {
1604         for (var i = elements.Length - 1; i >= 0; i--)
1605         {
1606             var element = elements[i];
1607             if (element != 0)
1608             {
1609                 results.Add(element);
1610             }
1611         }
1612     }
1613 }
1614
1615 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1616 public ulong[] GetRightElements(ulong startLink, ulong rightLink)
1617 {
1618     var result = new ulong[5];
1619     TryStepRight(startLink, rightLink, result, 0);
1620     Links.Each(Constants.Any, startLink, couple =>
1621     {
1622         if (couple != startLink)
1623         {
1624             if (TryStepRight(couple, rightLink, result, 2))
1625             {
1626                 return false;
1627             }
1628         }
1629         return true;
1630     });
1631     if (Links.GetTarget(Links.GetTarget(startLink)) == rightLink)
1632     {
1633         result[4] = startLink;
1634     }
1635     return result;
1636 }
1637
1638 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1639 public bool TryStepRight(ulong startLink, ulong rightLink, ulong[] result, int offset)
1640 {
1641     var added = 0;
1642     Links.Each(startLink, Constants.Any, couple =>
1643     {
1644         if (couple != startLink)
1645         {
1646             var coupleTarget = Links.GetTarget(couple);
1647             if (coupleTarget == rightLink)
1648             {
1649                 result[offset] = couple;
1650                 if (++added == 2)
1651                 {
1652                     return false;
1653                 }
1654             }
1655             else if (Links.GetSource(coupleTarget) == rightLink) // coupleTarget.Linker
1656                 ↪ == Net.And &&
1657             {
1658                 result[offset + 1] = couple;
1659                 if (++added == 2)
1660                 {
1661                     return false;
1662                 }
1663             }
1664         }
1665         return true;
1666     });
1667     return added > 0;

```

```

1667 }
1668
1669 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1670 public ulong[] GetLeftElements(ulong startLink, ulong leftLink)
1671 {
1672     var result = new ulong[5];
1673     TryStepLeft(startLink, leftLink, result, 0);
1674     Links.Each(startLink, Constants.Any, couple =>
1675     {
1676         if (couple != startLink)
1677         {
1678             if (TryStepLeft(couple, leftLink, result, 2))
1679             {
1680                 return false;
1681             }
1682         }
1683         return true;
1684     });
1685     if (Links.GetSource(Links.GetSource(leftLink)) == startLink)
1686     {
1687         result[4] = leftLink;
1688     }
1689     return result;
1690 }
1691
1692 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1693 public bool TryStepLeft(ulong startLink, ulong leftLink, ulong[] result, int offset)
1694 {
1695     var added = 0;
1696     Links.Each(Constants.Any, startLink, couple =>
1697     {
1698         if (couple != startLink)
1699         {
1700             var coupleSource = Links.GetSource(couple);
1701             if (coupleSource == leftLink)
1702             {
1703                 result[offset] = couple;
1704                 if (++added == 2)
1705                 {
1706                     return false;
1707                 }
1708             }
1709             else if (Links.GetTarget(coupleSource) == leftLink) // coupleSource.Linker
1710                 == Net.And &&
1711             {
1712                 result[offset + 1] = couple;
1713                 if (++added == 2)
1714                 {
1715                     return false;
1716                 }
1717             }
1718         }
1719         return true;
1720     });
1721     return added > 0;
1722 }
1723
1724 #endregion
1725
1726 #region Walkers
1727
1728 public class PatternMatcher : RightSequenceWalker<ulong>
1729 {
1730     private readonly Sequences _sequences;
1731     private readonly ulong[] _patternSequence;
1732     private readonly HashSet<LinkIndex> _linksInSequence;
1733     private readonly HashSet<LinkIndex> _results;
1734
1735     #region Pattern Match
1736
1737     enum PatternBlockType
1738     {
1739         Undefined,
1740         Gap,
1741         Elements
1742     }
1743
1744     struct PatternBlock
1745     {
1746         public PatternBlockType Type;
1747     }
1748 }

```

```

1746         public long Start;
1747         public long Stop;
1748     }
1749
1750     private readonly List<PatternBlock> _pattern;
1751     private int _patternPosition;
1752     private long _sequencePosition;
1753
1754     #endregion
1755
1756     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1757     public PatternMatcher(Sequences sequences, LinkIndex[] patternSequence,
1758         ↪ HashSet<LinkIndex> results)
1759         : base(sequences.Links.Unsync, new DefaultStack<ulong>())
1760     {
1761         _sequences = sequences;
1762         _patternSequence = patternSequence;
1763         _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
1764             ↪ _sequences.Constants.Any && x != ZeroOrMany));
1765         _results = results;
1766         _pattern = CreateDetailedPattern();
1767     }
1768
1769     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1770     protected override bool IsElement(ulong link) => _linksInSequence.Contains(link) ||
1771         ↪ base.IsElement(link);
1772
1773     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1774     public bool PatternMatch(LinkIndex sequenceToMatch)
1775     {
1776         _patternPosition = 0;
1777         _sequencePosition = 0;
1778         foreach (var part in Walk(sequenceToMatch))
1779         {
1780             if (!PatternMatchCore(part))
1781             {
1782                 break;
1783             }
1784         }
1785         return _patternPosition == _pattern.Count || (_patternPosition == _pattern.Count
1786             ↪ - 1 && _pattern[_patternPosition].Start == 0);
1787     }
1788
1789     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1790     private List<PatternBlock> CreateDetailedPattern()
1791     {
1792         var pattern = new List<PatternBlock>();
1793         var patternBlock = new PatternBlock();
1794         for (var i = 0; i < _patternSequence.Length; i++)
1795         {
1796             if (patternBlock.Type == PatternBlockType.Undefined)
1797             {
1798                 if (_patternSequence[i] == _sequences.Constants.Any)
1799                 {
1800                     patternBlock.Type = PatternBlockType.Gap;
1801                     patternBlock.Start = 1;
1802                     patternBlock.Stop = 1;
1803                 }
1804                 else if (_patternSequence[i] == ZeroOrMany)
1805                 {
1806                     patternBlock.Type = PatternBlockType.Gap;
1807                     patternBlock.Start = 0;
1808                     patternBlock.Stop = long.MaxValue;
1809                 }
1810                 else
1811                 {
1812                     patternBlock.Type = PatternBlockType.Elements;
1813                     patternBlock.Start = i;
1814                     patternBlock.Stop = i;
1815                 }
1816             }
1817             else if (patternBlock.Type == PatternBlockType.Elements)
1818             {
1819                 if (_patternSequence[i] == _sequences.Constants.Any)
1820                 {
1821                     pattern.Add(patternBlock);
1822                     patternBlock = new PatternBlock
1823                     {
1824                         Type = PatternBlockType.Gap,
1825                         Start = 1,

```

```

1822         Stop = 1
1823     };
1824 }
1825 else if (_patternSequence[i] == ZeroOrMany)
1826 {
1827     pattern.Add(patternBlock);
1828     patternBlock = new PatternBlock
1829     {
1830         Type = PatternBlockType.Gap,
1831         Start = 0,
1832         Stop = long.MaxValue
1833     };
1834 }
1835 else
1836 {
1837     patternBlock.Stop = i;
1838 }
1839 }
1840 else // patternBlock.Type == PatternBlockType.Gap
1841 {
1842     if (_patternSequence[i] == _sequences.Constants.Any)
1843     {
1844         patternBlock.Start++;
1845         if (patternBlock.Stop < patternBlock.Start)
1846         {
1847             patternBlock.Stop = patternBlock.Start;
1848         }
1849     }
1850     else if (_patternSequence[i] == ZeroOrMany)
1851     {
1852         patternBlock.Stop = long.MaxValue;
1853     }
1854     else
1855     {
1856         pattern.Add(patternBlock);
1857         patternBlock = new PatternBlock
1858         {
1859             Type = PatternBlockType.Elements,
1860             Start = i,
1861             Stop = i
1862         };
1863     }
1864 }
1865 }
1866 if (patternBlock.Type != PatternBlockType.Undefined)
1867 {
1868     pattern.Add(patternBlock);
1869 }
1870 return pattern;
1871 }
1872
1873 // match: search for regexp anywhere in text
1874 //int match(char* regexp, char* text)
1875 //{
1876 //    do
1877 //    {
1878 //    } while (*text++ != '\0');
1879 //    return 0;
1880 //}
1881
1882 // matchhere: search for regexp at beginning of text
1883 //int matchhere(char* regexp, char* text)
1884 //{
1885 //    if (regexp[0] == '\0')
1886 //        return 1;
1887 //    if (regexp[1] == '*')
1888 //        return matchstar(regexp[0], regexp + 2, text);
1889 //    if (regexp[0] == '$' && regexp[1] == '\0')
1890 //        return *text == '\0';
1891 //    if (*text != '\0' && (regexp[0] == '.' || regexp[0] == *text))
1892 //        return matchhere(regexp + 1, text + 1);
1893 //    return 0;
1894 //}
1895
1896 // matchstar: search for c*regexp at beginning of text
1897 //int matchstar(int c, char* regexp, char* text)
1898 //{
1899 //    do
1900 //    {
1901 //        /* a * matches zero or more instances */

```

```

1901         //         if (matchhere(regexp, text))
1902             //             return 1;
1903         //     } while (*text != '\0' && (*text++ == c || c == '.'));
1904         //     return 0;
1905         //}
1906
1907         //private void GetNextPatternElement(out LinkIndex element, out long mininumGap, out
1908         //    ↳ long maximumGap)
1909         //{
1910         //     mininumGap = 0;
1911         //     maximumGap = 0;
1912         //     element = 0;
1913         //     for (; _patternPosition < _patternSequence.Length; _patternPosition++)
1914         //     {
1915         //         if (_patternSequence[_patternPosition] == Doublets.Links.Null)
1916         //             mininumGap++;
1917         //         else if (_patternSequence[_patternPosition] == ZeroOrMany)
1918         //             maximumGap = long.MaxValue;
1919         //         else
1920         //             break;
1921         //     }
1922
1923         //     if (maximumGap < mininumGap)
1924         //         maximumGap = mininumGap;
1925         //}
1926
1927         [MethodImpl(MethodImplOptions.AggressiveInlining)]
1928         private bool PatternMatchCore(LinkIndex element)
1929         {
1930             if (_patternPosition >= _pattern.Count)
1931             {
1932                 _patternPosition = -2;
1933                 return false;
1934             }
1935             var currentPatternBlock = _pattern[_patternPosition];
1936             if (currentPatternBlock.Type == PatternBlockType.Gap)
1937             {
1938                 //var currentMatchingBlockLength = (_sequencePosition -
1939                 //    ↳ _lastMatchedBlockPosition);
1940                 if (_sequencePosition < currentPatternBlock.Start)
1941                 {
1942                     _sequencePosition++;
1943                     return true; // Двигаемся дальше
1944                 }
1945                 // Это последний блок
1946                 if (_pattern.Count == _patternPosition + 1)
1947                 {
1948                     _patternPosition++;
1949                     _sequencePosition = 0;
1950                     return false; // Полное соответствие
1951                 }
1952                 else
1953                 {
1954                     if (_sequencePosition > currentPatternBlock.Stop)
1955                     {
1956                         return false; // Соответствие невозможно
1957                     }
1958                     var nextPatternBlock = _pattern[_patternPosition + 1];
1959                     if (_patternSequence[nextPatternBlock.Start] == element)
1960                     {
1961                         if (nextPatternBlock.Start < nextPatternBlock.Stop)
1962                         {
1963                             _patternPosition++;
1964                             _sequencePosition = 1;
1965                         }
1966                         else
1967                         {
1968                             _patternPosition += 2;
1969                             _sequencePosition = 0;
1970                         }
1971                     }
1972                 }
1973             }
1974             else // currentPatternBlock.Type == PatternBlockType.Elements
1975             {
1976                 var patternElementPosition = currentPatternBlock.Start + _sequencePosition;
1977                 if (_patternSequence[patternElementPosition] != element)
1978                 {
1979                     return false; // Соответствие невозможно
1980                 }
1981             }
1982         }

```

```

1978     }
1979     if (patternElementPosition == currentPatternBlock.Stop)
1980     {
1981         _patternPosition++;
1982         _sequencePosition = 0;
1983     }
1984     else
1985     {
1986         _sequencePosition++;
1987     }
1988 }
1989 return true;
1990 //if (_patternSequence[_patternPosition] != element)
1991 //    return false;
1992 //else
1993 //{
1994 //    _sequencePosition++;
1995 //    _patternPosition++;
1996 //    return true;
1997 //}
1998 ///////////////
1999 //if (_filterPosition == _patternSequence.Length)
2000 //{
2001 //    _filterPosition = -2; // Длиннее чем нужно
2002 //    return false;
2003 //}
2004 //if (element != _patternSequence[_filterPosition])
2005 //{
2006 //    _filterPosition = -1;
2007 //    return false; // Начинается иначе
2008 //}
2009 //filterPosition++;
2010 //if (_filterPosition == (_patternSequence.Length - 1))
2011 //    return false;
2012 //if (_filterPosition >= 0)
2013 //{
2014 //    if (element == _patternSequence[_filterPosition + 1])
2015 //        _filterPosition++;
2016 //    else
2017 //        return false;
2018 //}
2019 //if (_filterPosition < 0)
2020 //{
2021 //    if (element == _patternSequence[0])
2022 //        _filterPosition = 0;
2023 //}
2024 }
2025
2026 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2027 public void AddAllPatternMatchedToResults(IEnumerable<ulong> sequencesToMatch)
2028 {
2029     foreach (var sequenceToMatch in sequencesToMatch)
2030     {
2031         if (PatternMatch(sequenceToMatch))
2032         {
2033             _results.Add(sequenceToMatch);
2034         }
2035     }
2036 }
2037 }
2038
2039 #endregion
2040 }
2041 }

```

1.116 ./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 звездочкой.
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     ///
45     ///
46     /// Можно убрать зависимость от конкретной реализации Links,
47     /// на зависимость от абстрактного элемента, который может быть представлен несколькими
48     /// ↪ способами.
49     ///
50     /// Можно ли как-то сделать один общий интерфейс
51     ///
52     ///
53     /// Блокчейн и/или гит для распределённой записи транзакций.
54     ///
55     /// </remarks>
56     public partial class Sequences : ILinks<LinkIndex> // IList<string>, IList<LinkIndex[]>
57     ↪ (после завершения реализации Sequences)
58     {
59         /// <summary>Возвращает значение LinkIndex, обозначающее любое количество
60         ↪ связей.</summary>
61         public const LinkIndex ZeroOrMany = LinkIndex.MaxValue;
62
63         public SequencesOptions<LinkIndex> Options { get; }
64         public SynchronizedLinks<LinkIndex> Links { get; }
65         private readonly ISynchronization _sync;
66
67         public LinksConstants<LinkIndex> Constants { get; }
68
69         [MethodImpl(MethodImplOptions.AggressiveInlining)]
70         public Sequences(SynchronizedLinks<LinkIndex> links, SequencesOptions<LinkIndex> options)
71         {
72             Links = links;
73             _sync = links.SyncRoot;
74             Options = options;
75             Options.ValidateOptions();
76             Options.InitOptions(Links);
77             Constants = links.Constants;
78         }
79
80         [MethodImpl(MethodImplOptions.AggressiveInlining)]
81         public Sequences(SynchronizedLinks<LinkIndex> links) : this(links, new
82         ↪ SequencesOptions<LinkIndex>()) { }
83
84         [MethodImpl(MethodImplOptions.AggressiveInlining)]
85         public bool IsSequence(LinkIndex sequence)
86         {
87             return _sync.ExecuteReadOperation(() =>
88             {
89                 if (Options.UseSequenceMarker)
90                 {
91                     return Options.MarkedSequenceMatcher.IsMatched(sequence);
92                 }
93             });
94         }
95     }
96 }

```



```

84         return !Links.Unsync.IsPartialPoint(sequence);
85     });
86 }
87
88 [MethodImpl(MethodImplOptions.AggressiveInlining)]
89 private LinkIndex GetSequenceByElements(LinkIndex sequence)
90 {
91     if (Options.UseSequenceMarker)
92     {
93         return Links.SearchOrDefault(Options.SequenceMarkerLink, sequence);
94     }
95     return sequence;
96 }
97
98 [MethodImpl(MethodImplOptions.AggressiveInlining)]
99 private LinkIndex GetSequenceElements(LinkIndex sequence)
100 {
101     if (Options.UseSequenceMarker)
102     {
103         var linkContents = new Link<ulong>(Links.GetLink(sequence));
104         if (linkContents.Source == Options.SequenceMarkerLink)
105         {
106             return linkContents.Target;
107         }
108         if (linkContents.Target == Options.SequenceMarkerLink)
109         {
110             return linkContents.Source;
111         }
112     }
113     return sequence;
114 }
115
116 #region Count
117
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 public LinkIndex Count(ICollection<LinkIndex> restrictions)
120 {
121     if (restrictions.IsNullOrEmpty())
122     {
123         return Links.Count(Constants.Any, Options.SequenceMarkerLink, Constants.Any);
124     }
125     if (restrictions.Count == 1) // Первая связь это адрес
126     {
127         var sequenceIndex = restrictions[0];
128         if (sequenceIndex == Constants.Null)
129         {
130             return 0;
131         }
132         if (sequenceIndex == Constants.Any)
133         {
134             return Count(null);
135         }
136         if (Options.UseSequenceMarker)
137         {
138             return Links.Count(Constants.Any, Options.SequenceMarkerLink, sequenceIndex);
139         }
140         return Links.Exists(sequenceIndex) ? 1UL : 0;
141     }
142     throw new NotImplementedException();
143 }
144
145 [MethodImpl(MethodImplOptions.AggressiveInlining)]
146 private LinkIndex CountUsages(params LinkIndex[] restrictions)
147 {
148     if (restrictions.Length == 0)
149     {
150         return 0;
151     }
152     if (restrictions.Length == 1) // Первая связь это адрес
153     {
154         if (restrictions[0] == Constants.Null)
155         {
156             return 0;
157         }
158         var any = Constants.Any;
159         if (Options.UseSequenceMarker)
160         {
161             var elementsLink = GetSequenceElements(restrictions[0]);
162             var sequenceLink = GetSequenceByElements(elementsLink);

```

```

163         if (sequenceLink != Constants.Null)
164         {
165             return Links.Count(any, sequenceLink) + Links.Count(any, elementsLink) -
                ↪ 1;
166         }
167         return Links.Count(any, elementsLink);
168     }
169     return Links.Count(any, restrictions[0]);
170 }
171 throw new NotImplementedException();
172 }
173
174 #endregion
175
176 #region Create
177
178 [MethodImpl(MethodImplOptions.AggressiveInlining)]
179 public LinkIndex Create(ICollection<LinkIndex> restrictions)
180 {
181     return _sync.ExecuteWriteOperation(() =>
182     {
183         if (restrictions.IsNullOrEmpty())
184         {
185             return Constants.Null;
186         }
187         Links.EnsureInnerReferenceExists(restrictions, nameof(restrictions));
188         return CreateCore(restrictions);
189     });
190 }
191
192 [MethodImpl(MethodImplOptions.AggressiveInlining)]
193 private LinkIndex CreateCore(ICollection<LinkIndex> restrictions)
194 {
195     LinkIndex[] sequence = restrictions.SkipFirst();
196     if (Options.UseIndex)
197     {
198         Options.Index.Add(sequence);
199     }
200     var sequenceRoot = default(LinkIndex);
201     if (Options.EnforceSingleSequenceVersionOnWriteBasedOnExisting)
202     {
203         var matches = Each(restrictions);
204         if (matches.Count > 0)
205         {
206             sequenceRoot = matches[0];
207         }
208     }
209     else if (Options.EnforceSingleSequenceVersionOnWriteBasedOnNew)
210     {
211         return CompactCore(sequence);
212     }
213     if (sequenceRoot == default)
214     {
215         sequenceRoot = Options.LinksToSequenceConverter.Convert(sequence);
216     }
217     if (Options.UseSequenceMarker)
218     {
219         return Links.Unsync.GetOrCreate(Options.SequenceMarkerLink, sequenceRoot);
220     }
221     return sequenceRoot; // Возвращаем корень последовательности (т.е. сами элементы)
222 }
223
224 #endregion
225
226 #region Each
227
228 [MethodImpl(MethodImplOptions.AggressiveInlining)]
229 public List<LinkIndex> Each(ICollection<LinkIndex> sequence)
230 {
231     var results = new List<LinkIndex>();
232     var filler = new ListFiller<LinkIndex, LinkIndex>(results, Constants.Continue);
233     Each(filler.AddFirstAndReturnConstant, sequence);
234     return results;
235 }
236
237 [MethodImpl(MethodImplOptions.AggressiveInlining)]
238 public LinkIndex Each(Func<ICollection<LinkIndex>, LinkIndex> handler, ICollection<LinkIndex>
    ↪ restrictions)
239 {

```

```

240     return _sync.ExecuteReadOperation(()=>
241     {
242         if (restrictions.IsNullOrEmpty())
243         {
244             return Constants.Continue;
245         }
246         Links.EnsureInnerReferenceExists(restrictions, nameof(restrictions));
247         if (restrictions.Count == 1)
248         {
249             var link = restrictions[0];
250             var any = Constants.Any;
251             if (link == any)
252             {
253                 if (Options.UseSequenceMarker)
254                 {
255                     return Links.Unsync.Each(handler, new Link<LinkIndex>(any,
256                                     ↳ Options.SequenceMarkerLink, any));
257                 }
258                 else
259                 {
260                     return Links.Unsync.Each(handler, new Link<LinkIndex>(any, any,
261                                     ↳ any));
262                 }
263             }
264             if (Options.UseSequenceMarker)
265             {
266                 var sequenceLinkValues = Links.Unsync.GetLink(link);
267                 if (sequenceLinkValues[Constants.SourcePart] ==
268                     ↳ Options.SequenceMarkerLink)
269                 {
270                     link = sequenceLinkValues[Constants.TargetPart];
271                 }
272             }
273             var sequence = Options.Walker.Walk(link).ToArray().ShiftRight();
274             sequence[0] = link;
275             return handler(sequence);
276         }
277         else if (restrictions.Count == 2)
278         {
279             throw new NotImplementedException();
280         }
281         else if (restrictions.Count == 3)
282         {
283             return Links.Unsync.Each(handler, restrictions);
284         }
285         else
286         {
287             var sequence = restrictions.SkipFirst();
288             if (Options.UseIndex && !Options.Index.MightContain(sequence))
289             {
290                 return Constants.Break;
291             }
292             return EachCore(handler, sequence);
293         }
294     });
295 }
296
297 [MethodImpl(MethodImplOptions.AggressiveInlining)]
298 private LinkIndex EachCore(Func<IList<LinkIndex>, LinkIndex> handler, IList<LinkIndex>
299     ↳ values)
300 {
301     var matcher = new Matcher(this, values, new HashSet<LinkIndex>(), handler);
302     // TODO: Find out why matcher.HandleFullMatched executed twice for the same sequence
303     ↳ Id.
304     Func<IList<LinkIndex>, LinkIndex> innerHandler = Options.UseSequenceMarker ?
305     ↳ (Func<IList<LinkIndex>, LinkIndex>)matcher.HandleFullMatchedSequence :
306     ↳ matcher.HandleFullMatched;
307     //if (sequence.Length >= 2)
308     if (StepRight(innerHandler, values[0], values[1]) != Constants.Continue)
309     {
310         return Constants.Break;
311     }
312     var last = values.Count - 2;
313     for (var i = 1; i < last; i++)
314     {
315         if (PartialStepRight(innerHandler, values[i], values[i + 1]) !=
316             ↳ Constants.Continue)
317         {
318             return Constants.Break;
319         }
320     }
321     return innerHandler(values);
322 }

```

```

310         return Constants.Break;
311     }
312 }
313 if (values.Count >= 3)
314 {
315     if (StepLeft(innerHandler, values[values.Count - 2], values[values.Count - 1])
        ↪ != Constants.Continue)
316     {
317         return Constants.Break;
318     }
319 }
320 return Constants.Continue;
321 }
322
323 [MethodImpl(MethodImplOptions.AggressiveInlining)]
324 private LinkIndex PartialStepRight(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
    ↪ left, LinkIndex right)
325 {
326     return Links.Unsync.Each(doublet =>
327     {
328         var doubletIndex = doublet[Constants.IndexPart];
329         if (StepRight(handler, doubletIndex, right) != Constants.Continue)
330         {
331             return Constants.Break;
332         }
333         if (left != doubletIndex)
334         {
335             return PartialStepRight(handler, doubletIndex, right);
336         }
337         return Constants.Continue;
338     }, new Link<LinkIndex>(Constants.Any, Constants.Any, left));
339 }
340
341 [MethodImpl(MethodImplOptions.AggressiveInlining)]
342 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));
343
344 [MethodImpl(MethodImplOptions.AggressiveInlining)]
345 private LinkIndex TryStepRightUp(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
    ↪ right, LinkIndex stepFrom)
346 {
347     var upStep = stepFrom;
348     var firstSource = Links.Unsync.GetTarget(upStep);
349     while (firstSource != right && firstSource != upStep)
350     {
351         upStep = firstSource;
352         firstSource = Links.Unsync.GetSource(upStep);
353     }
354     if (firstSource == right)
355     {
356         return handler(new LinkAddress<LinkIndex>(stepFrom));
357     }
358     return Constants.Continue;
359 }
360
361 [MethodImpl(MethodImplOptions.AggressiveInlining)]
362 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));
363
364 [MethodImpl(MethodImplOptions.AggressiveInlining)]
365 private LinkIndex TryStepLeftUp(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
    ↪ left, LinkIndex stepFrom)
366 {
367     var upStep = stepFrom;
368     var firstTarget = Links.Unsync.GetSource(upStep);
369     while (firstTarget != left && firstTarget != upStep)
370     {
371         upStep = firstTarget;
372         firstTarget = Links.Unsync.GetTarget(upStep);
373     }
374     if (firstTarget == left)
375     {
376         return handler(new LinkAddress<LinkIndex>(stepFrom));
377     }

```

```

378         return Constants.Continue;
379     }
380
381     #endregion
382
383     #region Update
384
385     [MethodImpl(MethodImplOptions.AggressiveInlining)]
386     public LinkIndex Update(IList<LinkIndex> restrictions, IList<LinkIndex> substitution)
387     {
388         var sequence = restrictions.SkipFirst();
389         var newSequence = substitution.SkipFirst();
390         if (sequence.IsNullOrEmpty() && newSequence.IsNullOrEmpty())
391         {
392             return Constants.Null;
393         }
394         if (sequence.IsNullOrEmpty())
395         {
396             return Create(substitution);
397         }
398         if (newSequence.IsNullOrEmpty())
399         {
400             Delete(restrictions);
401             return Constants.Null;
402         }
403         return _sync.ExecuteWriteOperation((Func<ulong>)(() =>
404         {
405             ILinksExtensions.EnsureLinkIsAnyOrExists<ulong>(Links, (IList<ulong>)sequence);
406             Links.EnsureLinkExists(newSequence);
407             return UpdateCore(sequence, newSequence);
408         })));
409     }
410
411     [MethodImpl(MethodImplOptions.AggressiveInlining)]
412     private LinkIndex UpdateCore(IList<LinkIndex> sequence, IList<LinkIndex> newSequence)
413     {
414         LinkIndex bestVariant;
415         if (Options.EnforceSingleSequenceVersionOnWriteBasedOnNew &&
416             ↪ !sequence.EqualTo(newSequence))
417         {
418             bestVariant = CompactCore(newSequence);
419         }
420         else
421         {
422             bestVariant = CreateCore(newSequence);
423         }
424         // TODO: Check all options only ones before loop execution
425         // Возможно нужно две версии Each, возвращающий фактические последовательности и с
426         ↪ маркером,
427         // или возможно даже возвращать и тот и тот вариант. С другой стороны все варианты
428         ↪ можно получить имея только фактические последовательности.
429         foreach (var variant in Each(sequence))
430         {
431             if (variant != bestVariant)
432             {
433                 UpdateOneCore(variant, bestVariant);
434             }
435         }
436         return bestVariant;
437     }
438
439     [MethodImpl(MethodImplOptions.AggressiveInlining)]
440     private void UpdateOneCore(LinkIndex sequence, LinkIndex newSequence)
441     {
442         if (Options.UseGarbageCollection)
443         {
444             var sequenceElements = GetSequenceElements(sequence);
445             var sequenceElementsContents = new Link<ulong>(Links.GetLink(sequenceElements));
446             var sequenceLink = GetSequenceByElements(sequenceElements);
447             var newSequenceElements = GetSequenceElements(newSequence);
448             var newSequenceLink = GetSequenceByElements(newSequenceElements);
449             if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
450             {
451                 if (sequenceLink != Constants.Null)
452                 {
453                     Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
454                 }
455                 Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
456             }
457         }
458     }

```

```

        ClearGarbage(sequenceElementsContents.Source);
        ClearGarbage(sequenceElementsContents.Target);
    }
    else
    {
        if (Options.UseSequenceMarker)
        {
            var sequenceElements = GetSequenceElements(sequence);
            var sequenceLink = GetSequenceByElements(sequenceElements);
            var newSequenceElements = GetSequenceElements(newSequence);
            var newSequenceLink = GetSequenceByElements(newSequenceElements);
            if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
            {
                if (sequenceLink != Constants.Null)
                {
                    Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
                }
                Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
            }
        }
        else
        {
            if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
            {
                Links.Unsync.MergeAndDelete(sequence, newSequence);
            }
        }
    }
}

#endregion

#region Delete

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public void Delete(IList<LinkIndex> restrictions)
{
    _sync.ExecuteWriteOperation(() =>
    {
        var sequence = restrictions.SkipFirst();
        // TODO: Check all options only ones before loop execution
        foreach (var linkToDelete in Each(sequence))
        {
            DeleteOneCore(linkToDelete);
        }
    });
}

[MethodImpl(MethodImplOptions.AggressiveInlining)]
private void DeleteOneCore(LinkIndex link)
{
    if (Options.UseGarbageCollection)
    {
        var sequenceElements = GetSequenceElements(link);
        var sequenceElementsContents = new Link<ulong>(Links.GetLink(sequenceElements));
        var sequenceLink = GetSequenceByElements(sequenceElements);
        if (Options.UseCascadeDelete || CountUsages(link) == 0)
        {
            if (sequenceLink != Constants.Null)
            {
                Links.Unsync.Delete(sequenceLink);
            }
            Links.Unsync.Delete(link);
        }
        ClearGarbage(sequenceElementsContents.Source);
        ClearGarbage(sequenceElementsContents.Target);
    }
    else
    {
        if (Options.UseSequenceMarker)
        {
            var sequenceElements = GetSequenceElements(link);
            var sequenceLink = GetSequenceByElements(sequenceElements);
            if (Options.UseCascadeDelete || CountUsages(link) == 0)
            {
                if (sequenceLink != Constants.Null)
                {
                    Links.Unsync.Delete(sequenceLink);
                }
            }
        }
    }
}

```

```

532     }
533     Links.Unsync.Delete(link);
534 }
535 }
536 else
537 {
538     if (Options.UseCascadeDelete || CountUsages(link) == 0)
539     {
540         Links.Unsync.Delete(link);
541     }
542 }
543 }
544 }
545
546 #endregion
547
548 #region Compactification
549
550 [MethodImpl(MethodImplOptions.AggressiveInlining)]
551 public void CompactAll()
552 {
553     _sync.ExecuteWriteOperation(() =>
554     {
555         var sequences = Each((LinkAddress<LinkIndex>)Constants.Any);
556         for (int i = 0; i < sequences.Count; i++)
557         {
558             var sequence = this.ToList(sequences[i]);
559             Compact(sequence.ShiftRight());
560         }
561     });
562 }
563
564 /// <remarks>
565 /// bestVariant можно выбирать по максимальному числу использований,
566 /// но балансированный позволяет гарантировать уникальность (если есть возможность,
567 /// гарантировать его использование в других местах).
568 ///
569 /// Получается этот метод должен игнорировать Options.EnforceSingleSequenceVersionOnWrite
570 /// </remarks>
571 [MethodImpl(MethodImplOptions.AggressiveInlining)]
572 public LinkIndex Compact(ICollection<LinkIndex> sequence)
573 {
574     return _sync.ExecuteWriteOperation(() =>
575     {
576         if (sequence.IsNullOrEmpty())
577         {
578             return Constants.Null;
579         }
580         Links.EnsureInnerReferenceExists(sequence, nameof(sequence));
581         return CompactCore(sequence);
582     });
583 }
584
585 [MethodImpl(MethodImplOptions.AggressiveInlining)]
586 private LinkIndex CompactCore(ICollection<LinkIndex> sequence) => UpdateCore(sequence,
587     ↪ sequence);
588
589 #endregion
590
591 #region Garbage Collection
592
593 /// <remarks>
594 /// TODO: Добавить дополнительный обработчик / событие CanBeDeleted которое можно
595 ↪ определить извне или в унаследованном классе
596 /// </remarks>
597 [MethodImpl(MethodImplOptions.AggressiveInlining)]
598 private bool IsGarbage(LinkIndex link) => link != Options.SequenceMarkerLink &&
599     ↪ !Links.Unsync.IsPartialPoint(link) && Links.Count(Constants.Any, link) == 0;
600
601 [MethodImpl(MethodImplOptions.AggressiveInlining)]
602 private void ClearGarbage(LinkIndex link)
603 {
604     if (IsGarbage(link))
605     {
606         var contents = new Link<ulong>(Links.GetLink(link));
607         Links.Unsync.Delete(link);
608         ClearGarbage(contents.Source);
609         ClearGarbage(contents.Target);
610     }
611 }

```

```

}
#endregion

#region Walkers

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public bool EachPart(Func<LinkIndex, bool> handler, LinkIndex sequence)
{
    return _sync.ExecuteReadOperation(() =>
    {
        var links = Links.Unsync;
        foreach (var part in Options.Walker.Walk(sequence))
        {
            if (!handler(part))
            {
                return false;
            }
        }
        return true;
    });
}

public class Matcher : RightSequenceWalker<LinkIndex>
{
    private readonly Sequences _sequences;
    private readonly IList<LinkIndex> _patternSequence;
    private readonly HashSet<LinkIndex> _linksInSequence;
    private readonly HashSet<LinkIndex> _results;
    private readonly Func<IList<LinkIndex>, LinkIndex> _stopableHandler;
    private readonly HashSet<LinkIndex> _readAsElements;
    private int _filterPosition;

    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    public Matcher(Sequences sequences, IList<LinkIndex> patternSequence,
        ↳ HashSet<LinkIndex> results, Func<IList<LinkIndex>, LinkIndex> stopableHandler,
        ↳ HashSet<LinkIndex> readAsElements = null)
        : base(sequences.Links.Unsync, new DefaultStack<LinkIndex>())
    {
        _sequences = sequences;
        _patternSequence = patternSequence;
        _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
            ↳ _links.Constants.Any && x != ZeroOrMany));
        _results = results;
        _stopableHandler = stopableHandler;
        _readAsElements = readAsElements;
    }

    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    protected override bool IsElement(LinkIndex link) => base.IsElement(link) ||
        ↳ (_readAsElements != null && _readAsElements.Contains(link)) ||
        ↳ _linksInSequence.Contains(link);

    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    public bool FullMatch(LinkIndex sequenceToMatch)
    {
        _filterPosition = 0;
        foreach (var part in Walk(sequenceToMatch))
        {
            if (!FullMatchCore(part))
            {
                break;
            }
        }
        return _filterPosition == _patternSequence.Count;
    }

    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    private bool FullMatchCore(LinkIndex element)
    {
        if (_filterPosition == _patternSequence.Count)
        {
            _filterPosition = -2; // Длиннее чем нужно
            return false;
        }
        if (_patternSequence[_filterPosition] != _links.Constants.Any
            && element != _patternSequence[_filterPosition])
        {
            _filterPosition = -1;
            return false; // Начинается/Продолжается иначе
        }
    }
}

```



```

683     }
684     _filterPosition++;
685     return true;
686 }
687
688 [MethodImpl(MethodImplOptions.AggressiveInlining)]
689 public void AddFullMatchedToResults(ICollection<LinkIndex> restrictions)
690 {
691     var sequenceToMatch = restrictions[_links.Constants.IndexPart];
692     if (FullMatch(sequenceToMatch))
693     {
694         _results.Add(sequenceToMatch);
695     }
696 }
697
698 [MethodImpl(MethodImplOptions.AggressiveInlining)]
699 public LinkIndex HandleFullMatched(ICollection<LinkIndex> restrictions)
700 {
701     var sequenceToMatch = restrictions[_links.Constants.IndexPart];
702     if (FullMatch(sequenceToMatch) && _results.Add(sequenceToMatch))
703     {
704         return _stopableHandler(new LinkAddress<LinkIndex>(sequenceToMatch));
705     }
706     return _links.Constants.Continue;
707 }
708
709 [MethodImpl(MethodImplOptions.AggressiveInlining)]
710 public LinkIndex HandleFullMatchedSequence(ICollection<LinkIndex> restrictions)
711 {
712     var sequenceToMatch = restrictions[_links.Constants.IndexPart];
713     var sequence = _sequences.GetSequenceByElements(sequenceToMatch);
714     if (sequence != _links.Constants.Null && FullMatch(sequenceToMatch) &&
715         ↪ _results.Add(sequenceToMatch))
716     {
717         return _stopableHandler(new LinkAddress<LinkIndex>(sequence));
718     }
719     return _links.Constants.Continue;
720 }
721
722 /// <remarks>
723 /// TODO: Add support for LinksConstants.Any
724 /// </remarks>
725 [MethodImpl(MethodImplOptions.AggressiveInlining)]
726 public bool PartialMatch(LinkIndex sequenceToMatch)
727 {
728     _filterPosition = -1;
729     foreach (var part in Walk(sequenceToMatch))
730     {
731         if (!PartialMatchCore(part))
732         {
733             break;
734         }
735     }
736     return _filterPosition == _patternSequence.Count - 1;
737 }
738
739 [MethodImpl(MethodImplOptions.AggressiveInlining)]
740 private bool PartialMatchCore(LinkIndex element)
741 {
742     if (_filterPosition == (_patternSequence.Count - 1))
743     {
744         return false; // Нашлось
745     }
746     if (_filterPosition >= 0)
747     {
748         if (element == _patternSequence[_filterPosition + 1])
749         {
750             _filterPosition++;
751         }
752         else
753         {
754             _filterPosition = -1;
755         }
756     }
757     if (_filterPosition < 0)
758     {
759         if (element == _patternSequence[0])
760         {
761             _filterPosition = 0;
762         }
763     }

```

```

761     }
762     }
763     return true; // Ищем дальше
764 }
765
766 [MethodImpl(MethodImplOptions.AggressiveInlining)]
767 public void AddPartialMatchedToResults(LinkIndex sequenceToMatch)
768 {
769     if (PartialMatch(sequenceToMatch))
770     {
771         _results.Add(sequenceToMatch);
772     }
773 }
774
775 [MethodImpl(MethodImplOptions.AggressiveInlining)]
776 public LinkIndex HandlePartialMatched(ICollection<LinkIndex> restrictions)
777 {
778     var sequenceToMatch = restrictions[_links.Constants.IndexPart];
779     if (PartialMatch(sequenceToMatch))
780     {
781         return _stopableHandler(new LinkAddress<LinkIndex>(sequenceToMatch));
782     }
783     return _links.Constants.Continue;
784 }
785
786 [MethodImpl(MethodImplOptions.AggressiveInlining)]
787 public void AddAllPartialMatchedToResults(IEnumerable<LinkIndex> sequencesToMatch)
788 {
789     foreach (var sequenceToMatch in sequencesToMatch)
790     {
791         if (PartialMatch(sequenceToMatch))
792         {
793             _results.Add(sequenceToMatch);
794         }
795     }
796 }
797
798 [MethodImpl(MethodImplOptions.AggressiveInlining)]
799 public void AddAllPartialMatchedToResultsAndReadAsElements(IEnumerable<LinkIndex>
800 ↪ sequencesToMatch)
801 {
802     foreach (var sequenceToMatch in sequencesToMatch)
803     {
804         if (PartialMatch(sequenceToMatch))
805         {
806             _readAsElements.Add(sequenceToMatch);
807             _results.Add(sequenceToMatch);
808         }
809     }
810 }
811
812 #endregion
813 }
814 }

```

1.117 ./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      public static class SequencesExtensions
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public static TLink Create<TLink>(this ICollection<TLink> sequences, ICollection<TLink[]>
13         ↪ groupedSequence)
14         {
15             var finalSequence = new TLink[groupedSequence.Count];
16             for (var i = 0; i < finalSequence.Length; i++)
17             {
18                 var part = groupedSequence[i];
19                 finalSequence[i] = part.Length == 1 ? part[0] :
20                 ↪ sequences.Create(part.ShiftRight());
21             }
22             return sequences.Create(finalSequence.ShiftRight());
23         }
24     }
25 }

```

```

21     }
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     public static IList<TLink> ToList<TLink>(this ILinks<TLink> sequences, TLink sequence)
25     {
26         var list = new List<TLink>();
27         var filler = new ListFiller<TLink, TLink>(list, sequences.Constants.Break);
28         sequences.Each(filler.AddSkipFirstAndReturnConstant, new
29             ↳ LinkAddress<TLink>(sequence));
30         return list;
31     }
32 }

```

1.118 ./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     public class SequencesOptions<TLink> // TODO: To use type parameter <TLink> the
19         ↳ ILinks<TLink> must contain GetConstants function.
20     {
21         private static readonly EqualityComparer<TLink> _equalityComparer =
22             ↳ EqualityComparer<TLink>.Default;
23
24         public TLink SequenceMarkerLink
25         {
26             [MethodImpl(MethodImplOptions.AggressiveInlining)]
27             get;
28             [MethodImpl(MethodImplOptions.AggressiveInlining)]
29             set;
30         }
31
32         public bool UseCascadeUpdate
33         {
34             [MethodImpl(MethodImplOptions.AggressiveInlining)]
35             get;
36             [MethodImpl(MethodImplOptions.AggressiveInlining)]
37             set;
38         }
39
40         public bool UseCascadeDelete
41         {
42             [MethodImpl(MethodImplOptions.AggressiveInlining)]
43             get;
44             [MethodImpl(MethodImplOptions.AggressiveInlining)]
45             set;
46         }
47
48         public bool UseIndex
49         {
50             [MethodImpl(MethodImplOptions.AggressiveInlining)]
51             get;
52             [MethodImpl(MethodImplOptions.AggressiveInlining)]
53             set;
54         } // TODO: Update Index on sequence update/delete.
55
56         public bool UseSequenceMarker
57         {
58             [MethodImpl(MethodImplOptions.AggressiveInlining)]
59             get;
60             [MethodImpl(MethodImplOptions.AggressiveInlining)]
61             set;
62         }
63
64         public bool UseCompression
65         {
66             [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

65         get;
66         [MethodImpl(MethodImplOptions.AggressiveInlining)]
67         set;
68     }
69
70     public bool UseGarbageCollection
71     {
72         [MethodImpl(MethodImplOptions.AggressiveInlining)]
73         get;
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]
75         set;
76     }
77
78     public bool EnforceSingleSequenceVersionOnWriteBasedOnExisting
79     {
80         [MethodImpl(MethodImplOptions.AggressiveInlining)]
81         get;
82         [MethodImpl(MethodImplOptions.AggressiveInlining)]
83         set;
84     }
85
86     public bool EnforceSingleSequenceVersionOnWriteBasedOnNew
87     {
88         [MethodImpl(MethodImplOptions.AggressiveInlining)]
89         get;
90         [MethodImpl(MethodImplOptions.AggressiveInlining)]
91         set;
92     }
93
94     public MarkedSequenceCriterionMatcher<TLink> MarkedSequenceMatcher
95     {
96         [MethodImpl(MethodImplOptions.AggressiveInlining)]
97         get;
98         [MethodImpl(MethodImplOptions.AggressiveInlining)]
99         set;
100     }
101
102     public IConverter<IList<TLink>, TLink> LinksToSequenceConverter
103     {
104         [MethodImpl(MethodImplOptions.AggressiveInlining)]
105         get;
106         [MethodImpl(MethodImplOptions.AggressiveInlining)]
107         set;
108     }
109
110     public ISequenceIndex<TLink> Index
111     {
112         [MethodImpl(MethodImplOptions.AggressiveInlining)]
113         get;
114         [MethodImpl(MethodImplOptions.AggressiveInlining)]
115         set;
116     }
117
118     public ISequenceWalker<TLink> Walker
119     {
120         [MethodImpl(MethodImplOptions.AggressiveInlining)]
121         get;
122         [MethodImpl(MethodImplOptions.AggressiveInlining)]
123         set;
124     }
125
126     public bool ReadFullSequence
127     {
128         [MethodImpl(MethodImplOptions.AggressiveInlining)]
129         get;
130         [MethodImpl(MethodImplOptions.AggressiveInlining)]
131         set;
132     }
133
134     // TODO: Реализовать компактификацию при чтении
135     //public bool EnforceSingleSequenceVersionOnRead { get; set; }
136     //public bool UseRequestMarker { get; set; }
137     //public bool StoreRequestResults { get; set; }
138
139     [MethodImpl(MethodImplOptions.AggressiveInlining)]
140     public void InitOptions(ISynchronizedLinks<TLink> links)
141     {
142         if (UseSequenceMarker)
143         {
144             if (_equalityComparer.Equals(SequenceMarkerLink, links.Constants.Null))
145             {

```

```

146         SequenceMarkerLink = links.CreatePoint();
147     }
148     else
149     {
150         if (!links.Exists(SequenceMarkerLink))
151         {
152             var link = links.CreatePoint();
153             if (!_equalityComparer.Equals(link, SequenceMarkerLink))
154             {
155                 throw new InvalidOperationException("Cannot recreate sequence marker
156                     ↪ link.");
157             }
158         }
159         if (MarkedSequenceMatcher == null)
160         {
161             MarkedSequenceMatcher = new MarkedSequenceCriterionMatcher<TLink>(links,
162                 ↪ SequenceMarkerLink);
163         }
164         var balancedVariantConverter = new BalancedVariantConverter<TLink>(links);
165         if (UseCompression)
166         {
167             if (LinksToSequenceConverter == null)
168             {
169                 ICounter<TLink, TLink> totalSequenceSymbolFrequencyCounter;
170                 if (UseSequenceMarker)
171                 {
172                     totalSequenceSymbolFrequencyCounter = new
173                         ↪ TotalMarkedSequenceSymbolFrequencyCounter<TLink>(links,
174                             ↪ MarkedSequenceMatcher);
175                 }
176                 else
177                 {
178                     totalSequenceSymbolFrequencyCounter = new
179                         ↪ TotalSequenceSymbolFrequencyCounter<TLink>(links);
180                 }
181                 var doubletFrequenciesCache = new LinkFrequenciesCache<TLink>(links,
182                     ↪ totalSequenceSymbolFrequencyCounter);
183                 var compressingConverter = new CompressingConverter<TLink>(links,
184                     ↪ balancedVariantConverter, doubletFrequenciesCache);
185                 LinksToSequenceConverter = compressingConverter;
186             }
187         }
188         else
189         {
190             if (LinksToSequenceConverter == null)
191             {
192                 LinksToSequenceConverter = balancedVariantConverter;
193             }
194         }
195         if (UseIndex && Index == null)
196         {
197             Index = new SequenceIndex<TLink>(links);
198         }
199         if (Walker == null)
200         {
201             Walker = new RightSequenceWalker<TLink>(links, new DefaultStack<TLink>());
202         }
203     }
204 }
205
206 [MethodImpl(MethodImplOptions.AggressiveInlining)]
207 public void ValidateOptions()
208 {
209     if (UseGarbageCollection && !UseSequenceMarker)
210     {
211         throw new NotSupportedException("To use garbage collection UseSequenceMarker
212             ↪ option must be on.");
213     }
214 }

```

1.119 ./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     public interface ISequenceWalker<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         IEnumerable<TLink> Walk(TLink sequence);
12     }
13 }

```

1.120 ./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     public class LeftSequenceWalker<TLink> : SequenceWalkerBase<TLink>
11     {
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public LeftSequenceWalker(ILinks<TLink> links, IStack<TLink> stack, Func<TLink, bool>
14             → isElement) : base(links, stack, isElement) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public LeftSequenceWalker(ILinks<TLink> links, IStack<TLink> stack) : base(links, stack,
18             → links.IsPartialPoint) { }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override TLink GetNextElementAfterPop(TLink element) =>
22             → _links.GetSource(element);
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected override TLink GetNextElementAfterPush(TLink element) =>
26             → _links.GetTarget(element);
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override IEnumerable<TLink> WalkContents(TLink element)
30         {
31             var links = _links;
32             var parts = links.GetLink(element);
33             var start = links.Constants.SourcePart;
34             for (var i = parts.Count - 1; i >= start; i--)
35             {
36                 var part = parts[i];
37                 if (IsElement(part))
38                 {
39                     yield return part;
40                 }
41             }
42         }
43     }
44 }

```

1.121 ./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     public class LeveledSequenceWalker<TLink> : LinksOperatorBase<TLink>, ISequenceWalker<TLink>
15     {
16         private static readonly EqualityComparer<TLink> _equalityComparer =
17             → EqualityComparer<TLink>.Default;
18
19         private readonly Func<TLink, bool> _isElement;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public LeveledSequenceWalker(ILinks<TLink> links, Func<TLink, bool> isElement) :
23             → base(links) => _isElement = isElement;
24     }
25 }

```

```

22     [MethodImpl(MethodImplOptions.AggressiveInlining)]
23     public LeveledSequenceWalker(ILinks<TLink> links) : base(links) => _isElement =
24         ↪ _links.IsPartialPoint;
25
26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     public IEnumerable<TLink> Walk(TLink sequence) => ToArray(sequence);
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     public TLink[] ToArray(TLink sequence)
31     {
32         var length = 1;
33         var array = new TLink[length];
34         array[0] = sequence;
35         if (_isElement(sequence))
36         {
37             return array;
38         }
39         bool hasElements;
40         do
41         {
42             length *= 2;
43             #if USEARRAYPOOL
44                 var nextArray = ArrayPool.Allocate<ulong>(length);
45             #else
46                 var nextArray = new TLink[length];
47             #endif
48             hasElements = false;
49             for (var i = 0; i < array.Length; i++)
50             {
51                 var candidate = array[i];
52                 if (_equalityComparer.Equals(array[i], default))
53                 {
54                     continue;
55                 }
56                 var doubletOffset = i * 2;
57                 if (_isElement(candidate))
58                 {
59                     nextArray[doubletOffset] = candidate;
60                 }
61                 else
62                 {
63                     var links = _links;
64                     var link = links.GetLink(candidate);
65                     var linkSource = links.GetSource(link);
66                     var linkTarget = links.GetTarget(link);
67                     nextArray[doubletOffset] = linkSource;
68                     nextArray[doubletOffset + 1] = linkTarget;
69                     if (!hasElements)
70                     {
71                         hasElements = !(_isElement(linkSource) && _isElement(linkTarget));
72                     }
73                 }
74             }
75             #if USEARRAYPOOL
76                 if (array.Length > 1)
77                 {
78                     ArrayPool.Free(array);
79                 }
80             #endif
81             array = nextArray;
82         }
83         while (hasElements);
84         var filledElementsCount = CountFilledElements(array);
85         if (filledElementsCount == array.Length)
86         {
87             return array;
88         }
89         else
90         {
91             return CopyFilledElements(array, filledElementsCount);
92         }
93     }
94
95     [MethodImpl(MethodImplOptions.AggressiveInlining)]
96     private static TLink[] CopyFilledElements(TLink[] array, int filledElementsCount)
97     {
98         var finalArray = new TLink[filledElementsCount];
99         for (int i = 0, j = 0; i < array.Length; i++)

```

```

100     {
101         if (!_equalityComparer.Equals(array[i], default))
102         {
103             finalArray[j] = array[i];
104             j++;
105         }
106     }
107     #if USEARRAYPOOL
108         ArrayPool.Free(array);
109     #endif
110     return finalArray;
111 }
112
113 [MethodImpl(MethodImplOptions.AggressiveInlining)]
114 private static int CountFilledElements(TLink[] array)
115 {
116     var count = 0;
117     for (var i = 0; i < array.Length; i++)
118     {
119         if (!_equalityComparer.Equals(array[i], default))
120         {
121             count++;
122         }
123     }
124     return count;
125 }
126 }
127 }

```

1.122 ./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     public class RightSequenceWalker<TLink> : SequenceWalkerBase<TLink>
11     {
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public RightSequenceWalker(ILinks<TLink> links, IStack<TLink> stack, Func<TLink, bool>
14             ↪ isElement) : base(links, stack, isElement) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public RightSequenceWalker(ILinks<TLink> links, IStack<TLink> stack) : base(links,
18             ↪ stack, links.IsPartialPoint) { }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override TLink GetNextElementAfterPop(TLink element) =>
22             ↪ _links.GetTarget(element);
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected override TLink GetNextElementAfterPush(TLink element) =>
26             ↪ _links.GetSource(element);
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override IEnumerable<TLink> WalkContents(TLink element)
30         {
31             var parts = _links.GetLink(element);
32             for (var i = _links.Constants.SourcePart; i < parts.Count; i++)
33             {
34                 var part = parts[i];
35                 if (IsElement(part))
36                 {
37                     yield return part;
38                 }
39             }
40         }
41     }
42 }

```

1.123 ./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     public abstract class SequenceWalkerBase<TLink> : LinksOperatorBase<TLink>,
11         ↳ ISequenceWalker<TLink>
12     {
13         private readonly IStack<TLink> _stack;
14         private readonly Func<TLink, bool> _isElement;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected SequenceWalkerBase(ILinks<TLink> links, IStack<TLink> stack, Func<TLink, bool>
18             ↳ isElement) : base(links)
19         {
20             _stack = stack;
21             _isElement = isElement;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected SequenceWalkerBase(ILinks<TLink> links, IStack<TLink> stack) : this(links,
26             ↳ stack, links.IsPartialPoint) { }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public IEnumerable<TLink> Walk(TLink sequence)
30         {
31             _stack.Clear();
32             var element = sequence;
33             if (IsElement(element))
34             {
35                 yield return element;
36             }
37             else
38             {
39                 while (true)
40                 {
41                     if (IsElement(element))
42                     {
43                         if (_stack.IsEmpty)
44                         {
45                             break;
46                         }
47                         element = _stack.Pop();
48                         foreach (var output in WalkContents(element))
49                         {
50                             yield return output;
51                         }
52                         element = GetNextElementAfterPop(element);
53                     }
54                     else
55                     {
56                         _stack.Push(element);
57                         element = GetNextElementAfterPush(element);
58                     }
59                 }
60             }
61         }
62
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         protected virtual bool IsElement(TLink elementLink) => _isElement(elementLink);
65
66         [MethodImpl(MethodImplOptions.AggressiveInlining)]
67         protected abstract TLink GetNextElementAfterPop(TLink element);
68
69         [MethodImpl(MethodImplOptions.AggressiveInlining)]
70         protected abstract TLink GetNextElementAfterPush(TLink element);
71
72         [MethodImpl(MethodImplOptions.AggressiveInlining)]
73         protected abstract IEnumerable<TLink> WalkContents(TLink element);
74     }
75 }

```

1.124 ./csharp/Platform.Data.Doublets/Stacks/Stack.cs

```

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

```

```

9     public class Stack<TLink> : LinksOperatorBase<TLink>, IStack<TLink>
10    {
11        private static readonly EqualityComparer<TLink> _equalityComparer =
12            ↪ EqualityComparer<TLink>.Default;
13
14        private readonly TLink _stack;
15
16        public bool IsEmpty
17        {
18            [MethodImpl(MethodImplOptions.AggressiveInlining)]
19            get => _equalityComparer.Equals(Peek(), _stack);
20        }
21
22        [MethodImpl(MethodImplOptions.AggressiveInlining)]
23        public Stack(ILinks<TLink> links, TLink stack) : base(links) => _stack = stack;
24
25        [MethodImpl(MethodImplOptions.AggressiveInlining)]
26        private TLink GetStackMarker() => _links.GetSource(_stack);
27
28        [MethodImpl(MethodImplOptions.AggressiveInlining)]
29        private TLink GetTop() => _links.GetTarget(_stack);
30
31        [MethodImpl(MethodImplOptions.AggressiveInlining)]
32        public TLink Peek() => _links.GetTarget(GetTop());
33
34        [MethodImpl(MethodImplOptions.AggressiveInlining)]
35        public TLink Pop()
36        {
37            var element = Peek();
38            if (!_equalityComparer.Equals(element, _stack))
39            {
40                var top = GetTop();
41                var previousTop = _links.GetSource(top);
42                _links.Update(_stack, GetStackMarker(), previousTop);
43                _links.Delete(top);
44            }
45            return element;
46        }
47
48        [MethodImpl(MethodImplOptions.AggressiveInlining)]
49        public void Push(TLink element) => _links.Update(_stack, GetStackMarker(),
50            ↪ _links.GetOrCreate(GetTop(), element));
51    }

```

1.125 ./csharp/Platform.Data.Doublets/Stacks/StackExtensions.cs

```

1     using System.Runtime.CompilerServices;
2
3     #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5     namespace Platform.Data.Doublets.Stacks
6     {
7         public static class StackExtensions
8         {
9             [MethodImpl(MethodImplOptions.AggressiveInlining)]
10            public static TLink CreateStack<TLink>(this ILinks<TLink> links, TLink stackMarker)
11            {
12                var stackPoint = links.CreatePoint();
13                var stack = links.Update(stackPoint, stackMarker, stackPoint);
14                return stack;
15            }
16        }
17    }

```

1.126 ./csharp/Platform.Data.Doublets/SynchronizedLinks.cs

```

1     using System;
2     using System.Collections.Generic;
3     using System.Runtime.CompilerServices;
4     using Platform.Data.Doublets;
5     using Platform.Threading.Synchronization;
6
7     #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9     namespace Platform.Data.Doublets
10    {
11        /// <remarks>
12        /// TODO: Autogeneration of synchronized wrapper (decorator).
13        /// TODO: Try to unfold code of each method using IL generation for performance improvements.
14        /// TODO: Or even to unfold multiple layers of implementations.

```

```

15  /// </remarks>
16  public class SynchronizedLinks<TLinkAddress> : ISynchronizedLinks<TLinkAddress>
17  {
18      public LinksConstants<TLinkAddress> Constants
19      {
20          [MethodImpl(MethodImplOptions.AggressiveInlining)]
21          get;
22      }
23
24      public ISynchronization SyncRoot
25      {
26          [MethodImpl(MethodImplOptions.AggressiveInlining)]
27          get;
28      }
29
30      public ILinks<TLinkAddress> Sync
31      {
32          [MethodImpl(MethodImplOptions.AggressiveInlining)]
33          get;
34      }
35
36      public ILinks<TLinkAddress> Unsync
37      {
38          [MethodImpl(MethodImplOptions.AggressiveInlining)]
39          get;
40      }
41
42      [MethodImpl(MethodImplOptions.AggressiveInlining)]
43      public SynchronizedLinks(ILinks<TLinkAddress> links) : this(new
44          ↳ ReaderWriterLockSynchronization(), links) { }
45
46      [MethodImpl(MethodImplOptions.AggressiveInlining)]
47      public SynchronizedLinks(ISynchronization synchronization, ILinks<TLinkAddress> links)
48      {
49          SyncRoot = synchronization;
50          Sync = this;
51          Unsync = links;
52          Constants = links.Constants;
53      }
54
55      [MethodImpl(MethodImplOptions.AggressiveInlining)]
56      public TLinkAddress Count(IList<TLinkAddress> restriction) =>
57          ↳ SyncRoot.ExecuteReadOperation(restriction, Unsync.Count);
58
59      [MethodImpl(MethodImplOptions.AggressiveInlining)]
60      public TLinkAddress Each(Func<IList<TLinkAddress>, TLinkAddress> handler,
61          ↳ IList<TLinkAddress> restrictions) => SyncRoot.ExecuteReadOperation(handler,
62          ↳ restrictions, (handler1, restrictions1) => Unsync.Each(handler1, restrictions1));
63
64      [MethodImpl(MethodImplOptions.AggressiveInlining)]
65      public TLinkAddress Create(IList<TLinkAddress> restrictions) =>
66          ↳ SyncRoot.ExecuteWriteOperation(restrictions, Unsync.Create);
67
68      [MethodImpl(MethodImplOptions.AggressiveInlining)]
69      public TLinkAddress Update(IList<TLinkAddress> restrictions, IList<TLinkAddress>
70          ↳ substitution) => SyncRoot.ExecuteWriteOperation(restrictions, substitution,
71          ↳ Unsync.Update);
72
73      [MethodImpl(MethodImplOptions.AggressiveInlining)]
74      public void Delete(IList<TLinkAddress> restrictions) =>
75          ↳ SyncRoot.ExecuteWriteOperation(restrictions, Unsync.Delete);
76
77      //public T Trigger(IList<T> restriction, Func<IList<T>, IList<T>, T> matchedHandler,
78      //    ↳ IList<T> substitution, Func<IList<T>, IList<T>, T> substitutedHandler)
79      //{
80      //    if (restriction != null && substitution != null &&
81      //        ↳ !substitution.EqualTo(restriction))
82      //        return SyncRoot.ExecuteWriteOperation(restriction, matchedHandler,
83      //            ↳ substitution, substitutedHandler, Unsync.Trigger);
84      //    return SyncRoot.ExecuteReadOperation(restriction, matchedHandler, substitution,
85      //        ↳ substitutedHandler, Unsync.Trigger);
86      //}
87  }

```

1.127 ./csharp/Platform.Data.Doublets/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     public static class UInt64LinksExtensions
13     {
14         public static readonly LinksConstants<ulong> Constants =
15             ↪ Default<LinksConstants<ulong>>.Instance;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public static void UseUnicode(this ILinks<ulong> links) => UnicodeMap.InitNew(links);
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public static bool AnyLinkIsAny(this ILinks<ulong> links, params ulong[] sequence)
22         {
23             if (sequence == null)
24             {
25                 return false;
26             }
27             var constants = links.Constants;
28             for (var i = 0; i < sequence.Length; i++)
29             {
30                 if (sequence[i] == constants.Any)
31                 {
32                     return true;
33                 }
34             }
35             return false;
36         }
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         public static string FormatStructure(this ILinks<ulong> links, ulong linkIndex,
40             ↪ Func<Link<ulong>, bool> isElement, bool renderIndex = false, bool renderDebug =
41             ↪ false)
42         {
43             var sb = new StringBuilder();
44             var visited = new HashSet<ulong>();
45             links.AppendStructure(sb, visited, linkIndex, isElement, (innerSb, link) =>
46                 ↪ innerSb.Append(link.Index), renderIndex, renderDebug);
47             return sb.ToString();
48         }
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         public static string FormatStructure(this ILinks<ulong> links, ulong linkIndex,
52             ↪ Func<Link<ulong>, bool> isElement, Action<StringBuilder, Link<ulong>> appendElement,
53             ↪ bool renderIndex = false, bool renderDebug = false)
54         {
55             var sb = new StringBuilder();
56             var visited = new HashSet<ulong>();
57             links.AppendStructure(sb, visited, linkIndex, isElement, appendElement, renderIndex,
58                 ↪ renderDebug);
59             return sb.ToString();
60         }
61
62         [MethodImpl(MethodImplOptions.AggressiveInlining)]
63         public static void AppendStructure(this ILinks<ulong> links, StringBuilder sb,
64             ↪ HashSet<ulong> visited, ulong linkIndex, Func<Link<ulong>, bool> isElement,
65             ↪ Action<StringBuilder, Link<ulong>> appendElement, bool renderIndex = false, bool
66             ↪ renderDebug = false)
67         {
68             if (sb == null)
69             {
70                 throw new ArgumentNullException(nameof(sb));
71             }
72             if (linkIndex == Constants.Null || linkIndex == Constants.Any || linkIndex ==
73                 ↪ Constants.Itself)
74             {
75                 return;
76             }
77             if (links.Exists(linkIndex))
78             {
79                 if (visited.Add(linkIndex))
80                 {
81                     sb.Append('(');
82                 }
83             }
84         }
85     }
86 }

```

```

71     var link = new Link<ulong>(links.GetLink(linkIndex));
72     if (renderIndex)
73     {
74         sb.Append(link.Index);
75         sb.Append(':');
76     }
77     if (link.Source == link.Index)
78     {
79         sb.Append(link.Index);
80     }
81     else
82     {
83         var source = new Link<ulong>(links.GetLink(link.Source));
84         if (isElement(source))
85         {
86             appendElement(sb, source);
87         }
88         else
89         {
90             links.AppendStructure(sb, visited, source.Index, isElement,
91                 ↪ appendElement, renderIndex);
92         }
93     }
94     sb.Append(' ');
95     if (link.Target == link.Index)
96     {
97         sb.Append(link.Index);
98     }
99     else
100    {
101        var target = new Link<ulong>(links.GetLink(link.Target));
102        if (isElement(target))
103        {
104            appendElement(sb, target);
105        }
106        else
107        {
108            links.AppendStructure(sb, visited, target.Index, isElement,
109                ↪ appendElement, renderIndex);
110        }
111    }
112    sb.Append(')');
113    }
114    else
115    {
116        if (renderDebug)
117        {
118            sb.Append('*');
119        }
120        sb.Append(linkIndex);
121    }
122    }
123    }
124    }
125    }
126    }
127    }
128    }
129    }
130    }
131    }

```

1.128 ./csharp/Platform.Data.Doublets/UInt64LinksTransactionsLayer.cs

```

1  using System;
2  using System.Linq;
3  using System.Collections.Generic;
4  using System.IO;
5  using System.Runtime.CompilerServices;
6  using System.Threading;
7  using System.Threading.Tasks;
8  using Platform.Disposables;
9  using Platform.Timestamps;
10 using Platform.Unsafe;
11 using Platform.IO;
12 using Platform.Data.Doublets.Decorators;
13 using Platform.Exceptions;
14

```

```

15 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
16
17 namespace Platform.Data.Doublets
18 {
19     public class UInt64LinksTransactionsLayer : LinksDisposableDecoratorBase<ulong> //-V3073
20     {
21         /// <remarks>
22         /// Альтернативные варианты хранения трансформации (элемента транзакции):
23         ///
24         /// private enum TransitionType
25         /// {
26         ///     Creation,
27         ///     UpdateOf,
28         ///     UpdateTo,
29         ///     Deletion
30         /// }
31         ///
32         /// private struct Transition
33         /// {
34         ///     public ulong TransactionId;
35         ///     public UniqueTimestamp Timestamp;
36         ///     public TransactionItemType Type;
37         ///     public Link Source;
38         ///     public Link Linker;
39         ///     public Link Target;
40         /// }
41         ///
42         /// Или
43         ///
44         /// public struct TransitionHeader
45         /// {
46         ///     public ulong TransactionIdCombined;
47         ///     public ulong TimestampCombined;
48         ///
49         ///     public ulong TransactionId
50         ///     {
51         ///         get
52         ///         {
53         ///             return (ulong) mask & TransactionIdCombined;
54         ///         }
55         ///     }
56         ///
57         ///     public UniqueTimestamp Timestamp
58         ///     {
59         ///         get
60         ///         {
61         ///             return (UniqueTimestamp)mask & TransactionIdCombined;
62         ///         }
63         ///     }
64         ///
65         ///     public TransactionItemType Type
66         ///     {
67         ///         get
68         ///         {
69         ///             // Использовать по одному биту из TransactionId и Timestamp,
70         ///             // для значения в 2 бита, которое представляет тип операции
71         ///             throw new NotImplementedException();
72         ///         }
73         ///     }
74         /// }
75         ///
76         /// private struct Transition
77         /// {
78         ///     public TransitionHeader Header;
79         ///     public Link Source;
80         ///     public Link Linker;
81         ///     public Link Target;
82         /// }
83         ///
84         /// </remarks>
85         public struct Transition : IEquatable<Transition>
86         {
87             public static readonly long Size = Structure<Transition>.Size;
88
89             public readonly ulong TransactionId;
90             public readonly Link<ulong> Before;
91             public readonly Link<ulong> After;
92             public readonly Timestamp Timestamp;

```

```

93     [MethodImpl(MethodImplOptions.AggressiveInlining)]
94     public Transition(UniqueTimestampFactory uniqueTimestampFactory, ulong
95         ↳ transactionId, Link<ulong> before, Link<ulong> after)
96     {
97         TransactionId = transactionId;
98         Before = before;
99         After = after;
100         Timestamp = uniqueTimestampFactory.Create();
101     }
102
103     [MethodImpl(MethodImplOptions.AggressiveInlining)]
104     public Transition(UniqueTimestampFactory uniqueTimestampFactory, ulong
105         ↳ transactionId, Link<ulong> before) : this(uniqueTimestampFactory, transactionId,
106         ↳ before, default) { }
107
108     [MethodImpl(MethodImplOptions.AggressiveInlining)]
109     public Transition(UniqueTimestampFactory uniqueTimestampFactory, ulong
110         ↳ transactionId) : this(uniqueTimestampFactory, transactionId, default, default) {
111         ↳ }
112
113     [MethodImpl(MethodImplOptions.AggressiveInlining)]
114     public override string ToString() => $"{Timestamp} {TransactionId}: {Before} =>
115         ↳ {After}";
116
117     [MethodImpl(MethodImplOptions.AggressiveInlining)]
118     public override bool Equals(object obj) => obj is Transition transition ?
119         ↳ Equals(transition) : false;
120
121     [MethodImpl(MethodImplOptions.AggressiveInlining)]
122     public override int GetHashCode() => (TransactionId, Before, After,
123         ↳ Timestamp).GetHashCode();
124
125     [MethodImpl(MethodImplOptions.AggressiveInlining)]
126     public bool Equals(Transition other) => TransactionId == other.TransactionId &&
127         ↳ Before == other.Before && After == other.After && Timestamp == other.Timestamp;
128
129     [MethodImpl(MethodImplOptions.AggressiveInlining)]
130     public static bool operator ==(Transition left, Transition right) =>
131         ↳ left.Equals(right);
132
133     [MethodImpl(MethodImplOptions.AggressiveInlining)]
134     public static bool operator !=(Transition left, Transition right) => !(left ==
135         ↳ right);
136 }
137
138 /// <remarks>
139 /// Другие варианты реализации транзакций (атомарности):
140 /// 1. Разделение хранения значения связи ((Source Target) или (Source Linker
141   ↳ Target)) и индексов.
142 /// 2. Хранение трансформаций/операций в отдельном хранилище Links, но дополнительно
143   ↳ потребуется решить вопрос
144 /// со ссылками на внешние идентификаторы, или как-то иначе решить вопрос с
145   ↳ пересечениями идентификаторов.
146 ///
147 /// Где хранить промежуточный список транзакций?
148 ///
149 /// В оперативной памяти:
150 /// Минусы:
151 /// 1. Может усложнить систему, если она будет функционировать самостоятельно,
152   ↳ так как нужно отдельно выделять память под список трансформаций.
153 /// 2. Выделенной оперативной памяти может не хватить, в том случае,
154   ↳ если транзакция использует слишком много трансформаций.
155 /// -> Можно использовать жёсткий диск для слишком длинных транзакций.
156 /// -> Максимальный размер списка трансформаций можно ограничить / задать
157   ↳ константой.
158 /// 3. При подтверждении транзакции (Commit) все трансформации записываются разом
159   ↳ создавая задержку.
160 ///
161 /// На жёстком диске:
162 /// Минусы:
163 /// 1. Длительный отклик, на запись каждой трансформации.
164 /// 2. Лог транзакций дополнительно наполняется отменёнными транзакциями.
165   ↳ -> Это может решаться упаковкой/исключением дублирующих операций.
166   ↳ -> Также это может решаться тем, что короткие транзакции вообще
167       ↳ не будут записываться в случае отката.
168 /// 3. Перед тем как выполнять отмену операций транзакции нужно дождаться пока все
169   ↳ операции (трансформации)

```

```

154     ///      будут записаны в лог.
155     ///
156     /// </remarks>
157     public class Transaction : DisposableBase
158     {
159         private readonly Queue<Transition> _transitions;
160         private readonly UInt64LinksTransactionsLayer _layer;
161         public bool IsCommitted { get; private set; }
162         public bool IsReverted { get; private set; }
163
164         [MethodImpl(MethodImplOptions.AggressiveInlining)]
165         public Transaction(UInt64LinksTransactionsLayer layer)
166         {
167             _layer = layer;
168             if (_layer._currentTransactionId != 0)
169             {
170                 throw new NotSupportedException("Nested transactions not supported.");
171             }
172             IsCommitted = false;
173             IsReverted = false;
174             _transitions = new Queue<Transition>();
175             SetCurrentTransaction(layer, this);
176         }
177
178         [MethodImpl(MethodImplOptions.AggressiveInlining)]
179         public void Commit()
180         {
181             EnsureTransactionAllowsWriteOperations(this);
182             while (_transitions.Count > 0)
183             {
184                 var transition = _transitions.Dequeue();
185                 _layer._transitions.Enqueue(transition);
186             }
187             _layer._lastCommittedTransactionId = _layer._currentTransactionId;
188             IsCommitted = true;
189         }
190
191         [MethodImpl(MethodImplOptions.AggressiveInlining)]
192         private void Revert()
193         {
194             EnsureTransactionAllowsWriteOperations(this);
195             var transitionsToRevert = new Transition[_transitions.Count];
196             _transitions.CopyTo(transitionsToRevert, 0);
197             for (var i = transitionsToRevert.Length - 1; i >= 0; i--)
198             {
199                 _layer.RevertTransition(transitionsToRevert[i]);
200             }
201             IsReverted = true;
202         }
203
204         [MethodImpl(MethodImplOptions.AggressiveInlining)]
205         public static void SetCurrentTransaction(UInt64LinksTransactionsLayer layer,
206             ↪ Transaction transaction)
207         {
208             layer._currentTransactionId = layer._lastCommittedTransactionId + 1;
209             layer._currentTransactionTransitions = transaction._transitions;
210             layer._currentTransaction = transaction;
211         }
212
213         [MethodImpl(MethodImplOptions.AggressiveInlining)]
214         public static void EnsureTransactionAllowsWriteOperations(Transaction transaction)
215         {
216             if (transaction.IsReverted)
217             {
218                 throw new InvalidOperationException("Transation is reverted.");
219             }
220             if (transaction.IsCommitted)
221             {
222                 throw new InvalidOperationException("Transation is committed.");
223             }
224         }
225
226         [MethodImpl(MethodImplOptions.AggressiveInlining)]
227         protected override void Dispose(bool manual, bool wasDisposed)
228         {
229             if (!wasDisposed && _layer != null && !_layer.Disposable.IsDisposed)
230             {
231                 if (!IsCommitted && !IsReverted)
232                 {

```



```

232         Revert();
233     }
234     _layer.ResetCurrentTransation();
235 }
236 }
237 }
238
239 public static readonly TimeSpan DefaultPushDelay = TimeSpan.FromSeconds(0.1);
240
241 private readonly string _logAddress;
242 private readonly FileStream _log;
243 private readonly Queue<Transition> _transitions;
244 private readonly UniqueTimestampFactory _uniqueTimestampFactory;
245 private Task _transitionsPusher;
246 private Transition _lastCommittedTransition;
247 private ulong _currentTransactionId;
248 private Queue<Transition> _currentTransactionTransitions;
249 private Transaction _currentTransaction;
250 private ulong _lastCommittedTransactionId;
251
252 [MethodImpl(MethodImplOptions.AggressiveInlining)]
253 public UInt64LinksTransactionsLayer(ILinks<ulong> links, string logAddress)
254     : base(links)
255 {
256     if (string.IsNullOrEmpty(logAddress))
257     {
258         throw new ArgumentNullException(nameof(logAddress));
259     }
260     // В первой строке файла хранится последняя закоммиченную транзакцию.
261     // При запуске это используется для проверки удачного закрытия файла лога.
262     // In the first line of the file the last committed transaction is stored.
263     // On startup, this is used to check that the log file is successfully closed.
264     var lastCommittedTransition = FileHelpers.ReadFirstOrDefault<Transition>(logAddress);
265     var lastWrittenTransition = FileHelpers.ReadLastOrDefault<Transition>(logAddress);
266     if (!lastCommittedTransition.Equals(lastWrittenTransition))
267     {
268         Dispose();
269         throw new NotSupportedException("Database is damaged, autorecovery is not
270             ↳ supported yet.");
271     }
272     if (lastCommittedTransition == default)
273     {
274         FileHelpers.WriteFirst(logAddress, lastCommittedTransition);
275     }
276     _lastCommittedTransition = lastCommittedTransition;
277     // TODO: Think about a better way to calculate or store this value
278     var allTransitions = FileHelpers.ReadAll<Transition>(logAddress);
279     _lastCommittedTransactionId = allTransitions.Length > 0 ? allTransitions.Max(x =>
280         ↳ x.TransactionId) : 0;
281     _uniqueTimestampFactory = new UniqueTimestampFactory();
282     _logAddress = logAddress;
283     _log = FileHelpers.Append(logAddress);
284     _transitions = new Queue<Transition>();
285     _transitionsPusher = new Task(TransitionsPusher);
286     _transitionsPusher.Start();
287 }
288
289 [MethodImpl(MethodImplOptions.AggressiveInlining)]
290 public IList<ulong> GetLinkValue(ulong link) => _links.GetLink(link);
291
292 [MethodImpl(MethodImplOptions.AggressiveInlining)]
293 public override ulong Create(IList<ulong> restrictions)
294 {
295     var createdLinkIndex = _links.Create();
296     var createdLink = new Link<ulong>(_links.GetLink(createdLinkIndex));
297     CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
298         ↳ default, createdLink));
299     return createdLinkIndex;
300 }
301
302 [MethodImpl(MethodImplOptions.AggressiveInlining)]
303 public override ulong Update(IList<ulong> restrictions, IList<ulong> substitution)
304 {
305     var linkIndex = restrictions[_constants.IndexPart];
306     var beforeLink = new Link<ulong>(_links.GetLink(linkIndex));
307     linkIndex = _links.Update(restrictions, substitution);
308     var afterLink = new Link<ulong>(_links.GetLink(linkIndex));
309     CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
310         ↳ beforeLink, afterLink));

```

```

307         return linkIndex;
308     }
309
310     [MethodImpl(MethodImplOptions.AggressiveInlining)]
311     public override void Delete(ICollection<ulong> restrictions)
312     {
313         var link = restrictions[_constants.IndexPart];
314         var deletedLink = new Link<ulong>(_links.GetLink(link));
315         _links.Delete(link);
316         CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
317             ↪ deletedLink, default));
318     }
319
320     [MethodImpl(MethodImplOptions.AggressiveInlining)]
321     private Queue<Transition> GetCurrentTransitions() => _currentTransactionTransitions ??
322         ↪ _transitions;
323
324     [MethodImpl(MethodImplOptions.AggressiveInlining)]
325     private void CommitTransition(Transition transition)
326     {
327         if (_currentTransaction != null)
328         {
329             Transaction.EnsureTransactionAllowsWriteOperations(_currentTransaction);
330         }
331         var transitions = GetCurrentTransitions();
332         transitions.Enqueue(transition);
333     }
334
335     [MethodImpl(MethodImplOptions.AggressiveInlining)]
336     private void RevertTransition(Transition transition)
337     {
338         if (transition.After.IsNull()) // Revert Deletion with Creation
339         {
340             _links.Create();
341         }
342         else if (transition.Before.IsNull()) // Revert Creation with Deletion
343         {
344             _links.Delete(transition.After.Index);
345         }
346         else // Revert Update
347         {
348             _links.Update(new[] { transition.After.Index, transition.Before.Source,
349                 ↪ transition.Before.Target });
350         }
351     }
352
353     [MethodImpl(MethodImplOptions.AggressiveInlining)]
354     private void ResetCurrentTransation()
355     {
356         _currentTransactionId = 0;
357         _currentTransactionTransitions = null;
358         _currentTransaction = null;
359     }
360
361     [MethodImpl(MethodImplOptions.AggressiveInlining)]
362     private void PushTransitions()
363     {
364         if (_log == null || _transitions == null)
365         {
366             return;
367         }
368         for (var i = 0; i < _transitions.Count; i++)
369         {
370             var transition = _transitions.Dequeue();
371             _log.Write(transition);
372             _lastCommittedTransition = transition;
373         }
374     }
375
376     [MethodImpl(MethodImplOptions.AggressiveInlining)]
377     private void TransitionsPusher()
378     {
379         while (!Disposable.IsDisposed && _transitionsPusher != null)
380         {
381             Thread.Sleep(DefaultPushDelay);
382             PushTransitions();
383         }
384     }

```

```

382     }
383
384     [MethodImpl(MethodImplOptions.AggressiveInlining)]
385     public Transaction BeginTransaction() => new Transaction(this);
386
387     [MethodImpl(MethodImplOptions.AggressiveInlining)]
388     private void DisposeTransitions()
389     {
390         try
391         {
392             var pusher = _transitionsPusher;
393             if (pusher != null)
394             {
395                 _transitionsPusher = null;
396                 pusher.Wait();
397             }
398             if (_transitions != null)
399             {
400                 PushTransitions();
401             }
402             _log.DisposeIfPossible();
403             FileHelpers.WriteFirst(_logAddress, _lastCommittedTransition);
404         }
405         catch (Exception ex)
406         {
407             ex.Ignore();
408         }
409     }
410
411     #region DisposalBase
412
413     [MethodImpl(MethodImplOptions.AggressiveInlining)]
414     protected override void Dispose(bool manual, bool wasDisposed)
415     {
416         if (!wasDisposed)
417         {
418             DisposeTransitions();
419         }
420         base.Dispose(manual, wasDisposed);
421     }
422
423     #endregion
424 }
425 }

```

1.129 ./csharp/Platform.Data.Doublets/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      public class CharToUnicodeSymbolConverter<TLink> : LinksOperatorBase<TLink>,
9      ↪ IConverter<char, TLink>
10     {
11         private static readonly UncheckedConverter<char, TLink> _charToAddressConverter =
12         ↪ UncheckedConverter<char, TLink>.Default;
13
14         private readonly IConverter<TLink> _addressToNumberConverter;
15         private readonly TLink _unicodeSymbolMarker;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public CharToUnicodeSymbolConverter(ILinks<TLink> links, IConverter<TLink>
19         ↪ addressToNumberConverter, TLink unicodeSymbolMarker) : base(links)
20         {
21             _addressToNumberConverter = addressToNumberConverter;
22             _unicodeSymbolMarker = unicodeSymbolMarker;
23         }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public TLink Convert(char source)
27         {
28             var unaryNumber =
29             ↪ _addressToNumberConverter.Convert(_charToAddressConverter.Convert(source));
30             return _links.GetOrCreate(unaryNumber, _unicodeSymbolMarker);
31         }
32     }
33 }

```

1.130 ./csharp/Platform.Data.Doublets/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     public class StringToUnicodeSequenceConverter<TLink> : LinksOperatorBase<TLink>,
11         ↪ IConverter<string, TLink>
12     {
13         private readonly IConverter<string, IList<TLink>> _stringToUnicodeSymbolListConverter;
14         private readonly IConverter<IList<TLink>, TLink> _unicodeSymbolListToSequenceConverter;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<string,
18             ↪ IList<TLink>> stringToUnicodeSymbolListConverter, IConverter<IList<TLink>, TLink>
19             ↪ unicodeSymbolListToSequenceConverter) : base(links)
20         {
21             _stringToUnicodeSymbolListConverter = stringToUnicodeSymbolListConverter;
22             _unicodeSymbolListToSequenceConverter = unicodeSymbolListToSequenceConverter;
23         }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<string,
27             ↪ IList<TLink>> stringToUnicodeSymbolListConverter, ISequenceIndex<TLink> index,
28             ↪ IConverter<IList<TLink>, TLink> listToSequenceLinkConverter, TLink
29             ↪ unicodeSequenceMarker)
30             : this(links, stringToUnicodeSymbolListConverter, new
31                 ↪ UnicodeSymbolsListToUnicodeSequenceConverter<TLink>(links, index,
32                 ↪ listToSequenceLinkConverter, unicodeSequenceMarker)) { }
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<char, TLink>
36             ↪ charToUnicodeSymbolConverter, ISequenceIndex<TLink> index, IConverter<IList<TLink>,
37             ↪ TLink> listToSequenceLinkConverter, TLink unicodeSequenceMarker)
38             : this(links, new
39                 ↪ StringToUnicodeSymbolsListConverter<TLink>(charToUnicodeSymbolConverter), index,
40                 ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<char, TLink>
44             ↪ charToUnicodeSymbolConverter, IConverter<IList<TLink>, TLink>
45             ↪ listToSequenceLinkConverter, TLink unicodeSequenceMarker)
46             : this(links, charToUnicodeSymbolConverter, new Unindex<TLink>(),
47                 ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<string,
51             ↪ IList<TLink>> stringToUnicodeSymbolListConverter, IConverter<IList<TLink>, TLink>
52             ↪ listToSequenceLinkConverter, TLink unicodeSequenceMarker)
53             : this(links, stringToUnicodeSymbolListConverter, new Unindex<TLink>(),
54                 ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }
55
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]
57         public TLink Convert(string source)
58         {
59             var elements = _stringToUnicodeSymbolListConverter.Convert(source);
60             return _unicodeSymbolListToSequenceConverter.Convert(elements);
61         }
62     }
63 }

```

1.131 ./csharp/Platform.Data.Doublets/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     public class StringToUnicodeSymbolsListConverter<TLink> : IConverter<string, IList<TLink>>
10     {
11         private readonly IConverter<char, TLink> _charToUnicodeSymbolConverter;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

14     public StringToUnicodeSymbolsListConverter(IConverter<char, TLink>
    ↪ charToUnicodeSymbolConverter) => _charToUnicodeSymbolConverter =
    ↪ charToUnicodeSymbolConverter;
15
16     [MethodImpl(MethodImplOptions.AggressiveInlining)]
17     public IList<TLink> Convert(string source)
18     {
19         var elements = new TLink[source.Length];
20         for (var i = 0; i < elements.Length; i++)
21         {
22             elements[i] = _charToUnicodeSymbolConverter.Convert(source[i]);
23         }
24         return elements;
25     }
26 }
27 }

```

1.132 ./csharp/Platform.Data.Doublets/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     public class UnicodeMap
13     {
14         public static readonly ulong FirstCharLink = 1;
15         public static readonly ulong LastCharLink = FirstCharLink + char.MaxValue;
16         public static readonly ulong MapSize = 1 + char.MaxValue;
17
18         private readonly ILinks<ulong> _links;
19         private bool _initialized;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public UnicodeMap(ILinks<ulong> links) => _links = links;
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public static UnicodeMap InitNew(ILinks<ulong> links)
26         {
27             var map = new UnicodeMap(links);
28             map.Init();
29             return map;
30         }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public void Init()
34         {
35             if (_initialized)
36             {
37                 return;
38             }
39             _initialized = true;
40             var firstLink = _links.CreatePoint();
41             if (firstLink != FirstCharLink)
42             {
43                 _links.Delete(firstLink);
44             }
45             else
46             {
47                 for (var i = FirstCharLink + 1; i <= LastCharLink; i++)
48                 {
49                     // From NIL to It (NIL -> Character) transformation meaning, (or infinite
50                     ↪ amount of NIL characters before actual Character)
51                     var createdLink = _links.CreatePoint();
52                     _links.Update(createdLink, firstLink, createdLink);
53                     if (createdLink != i)
54                     {
55                         throw new InvalidOperationException("Unable to initialize UTF 16
56                         ↪ table.");
57                     }
58                 }
59             }
60             // 0- null link

```

```

61 // 1 - nil character (0 character)
62 // ...
63 // 65536 (0(1) + 65535 = 65536 possible values)
64
65 [MethodImpl(MethodImplOptions.AggressiveInlining)]
66 public static ulong FromCharToLink(char character) => (ulong)character + 1;
67
68 [MethodImpl(MethodImplOptions.AggressiveInlining)]
69 public static char FromLinkToChar(ulong link) => (char)(link - 1);
70
71 [MethodImpl(MethodImplOptions.AggressiveInlining)]
72 public static bool IsCharLink(ulong link) => link <= MapSize;
73
74 [MethodImpl(MethodImplOptions.AggressiveInlining)]
75 public static string FromLinksToString(IList<ulong> linksList)
76 {
77     var sb = new StringBuilder();
78     for (int i = 0; i < linksList.Count; i++)
79     {
80         sb.Append(FromLinkToChar(linksList[i]));
81     }
82     return sb.ToString();
83 }
84
85 [MethodImpl(MethodImplOptions.AggressiveInlining)]
86 public static string FromSequenceLinkToString(ulong link, ILinks<ulong> links)
87 {
88     var sb = new StringBuilder();
89     if (links.Exists(link))
90     {
91         StopableSequenceWalker.WalkRight(link, links.GetSource, links.GetTarget,
92             x => x <= MapSize || links.GetSource(x) == x || links.GetTarget(x) == x,
93             ↪ element =>
94             {
95                 sb.Append(FromLinkToChar(element));
96                 return true;
97             }
98         );
99     }
100     return sb.ToString();
101 }
102
103 [MethodImpl(MethodImplOptions.AggressiveInlining)]
104 public static ulong[] FromCharsToLinkArray(char[] chars) => FromCharsToLinkArray(chars,
105     ↪ chars.Length);
106
107 [MethodImpl(MethodImplOptions.AggressiveInlining)]
108 public static ulong[] FromCharsToLinkArray(char[] chars, int count)
109 {
110     // char array to ulong array
111     var linksSequence = new ulong[count];
112     for (var i = 0; i < count; i++)
113     {
114         linksSequence[i] = FromCharToLink(chars[i]);
115     }
116     return linksSequence;
117 }
118
119 [MethodImpl(MethodImplOptions.AggressiveInlining)]
120 public static ulong[] FromStringToLinkArray(string sequence)
121 {
122     // char array to ulong array
123     var linksSequence = new ulong[sequence.Length];
124     for (var i = 0; i < sequence.Length; i++)
125     {
126         linksSequence[i] = FromCharToLink(sequence[i]);
127     }
128     return linksSequence;
129 }
130
131 [MethodImpl(MethodImplOptions.AggressiveInlining)]
132 public static List<ulong[]> FromStringToLinkArrayGroups(string sequence)
133 {
134     var result = new List<ulong[]>();
135     var offset = 0;
136     while (offset < sequence.Length)
137     {
138         var currentCategory = CharUnicodeInfo.GetUnicodeCategory(sequence[offset]);
139         var relativeLength = 1;
140         var absoluteLength = offset + relativeLength;

```

```

138         while (absoluteLength < sequence.Length &&
139                currentCategory ==
140                    ↳ CharUnicodeInfo.GetUnicodeCategory(sequence[absoluteLength]))
141         {
142             relativeLength++;
143             absoluteLength++;
144         }
145         // char array to ulong array
146         var innerSequence = new ulong[relativeLength];
147         var maxLength = offset + relativeLength;
148         for (var i = offset; i < maxLength; i++)
149         {
150             innerSequence[i - offset] = FromCharToLink(sequence[i]);
151         }
152         result.Add(innerSequence);
153         offset += relativeLength;
154     }
155     return result;
156 }
157
158 [MethodImpl(MethodImplOptions.AggressiveInlining)]
159 public static List<ulong[]> FromLinkArrayToLinkArrayGroups(ulong[] array)
160 {
161     var result = new List<ulong[]>();
162     var offset = 0;
163     while (offset < array.Length)
164     {
165         var relativeLength = 1;
166         if (array[offset] <= LastCharLink)
167         {
168             var currentCategory =
169                 ↳ CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(array[offset]));
170             var absoluteLength = offset + relativeLength;
171             while (absoluteLength < array.Length &&
172                    array[absoluteLength] <= LastCharLink &&
173                    currentCategory == CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(
174                        ↳ array[absoluteLength])))
175             {
176                 relativeLength++;
177                 absoluteLength++;
178             }
179         }
180         else
181         {
182             var absoluteLength = offset + relativeLength;
183             while (absoluteLength < array.Length && array[absoluteLength] > LastCharLink)
184             {
185                 relativeLength++;
186                 absoluteLength++;
187             }
188         }
189         // copy array
190         var innerSequence = new ulong[relativeLength];
191         var maxLength = offset + relativeLength;
192         for (var i = offset; i < maxLength; i++)
193         {
194             innerSequence[i - offset] = array[i];
195         }
196         result.Add(innerSequence);
197         offset += relativeLength;
198     }
199     return result;
200 }

```

1.133 ./csharp/Platform.Data.Doublets/Unicode/UnicodeSequenceToStringConverter.cs

```

1 using System;
2 using System.Linq;
3 using System.Runtime.CompilerServices;
4 using Platform.Interfaces;
5 using Platform.Converters;
6 using Platform.Data.Doublets.Sequences.Walkers;
7
8 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Unicode
11 {
12     public class UnicodeSequenceToStringConverter<TLink> : LinksOperatorBase<TLink>,
13         ↳ IConverter<TLink, string>

```

```

13 {
14     private readonly ICriterionMatcher<TLink> _unicodeSequenceCriterionMatcher;
15     private readonly ISequenceWalker<TLink> _sequenceWalker;
16     private readonly IConverter<TLink, char> _unicodeSymbolToCharConverter;
17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     public UnicodeSequenceToStringConverter(ILinks<TLink> links, ICriterionMatcher<TLink>
        ↳ unicodeSequenceCriterionMatcher, ISequenceWalker<TLink> sequenceWalker,
        ↳ IConverter<TLink, char> unicodeSymbolToCharConverter) : base(links)
20     {
21         _unicodeSequenceCriterionMatcher = unicodeSequenceCriterionMatcher;
22         _sequenceWalker = sequenceWalker;
23         _unicodeSymbolToCharConverter = unicodeSymbolToCharConverter;
24     }
25
26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     public string Convert(TLink source)
28     {
29         if (!_unicodeSequenceCriterionMatcher.IsMatched(source))
30         {
31             throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
        ↳ not a unicode sequence.");
32         }
33         var sequence = _links.GetSource(source);
34         var charArray = _sequenceWalker.Walk(sequence).Select(_unicodeSymbolToCharConverter.
        ↳ Convert).ToArray();
35         return new string(charArray);
36     }
37 }
38 }

```

1.134 ./csharp/Platform.Data.Doublets/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     public class UnicodeSymbolToCharConverter<TLink> : LinksOperatorBase<TLink>,
        ↳ IConverter<TLink, char>
11     {
12         private static readonly UncheckedConverter<TLink, char> _addressToCharConverter =
        ↳ UncheckedConverter<TLink, char>.Default;
13
14         private readonly IConverter<TLink> _numberToAddressConverter;
15         private readonly ICriterionMatcher<TLink> _unicodeSymbolCriterionMatcher;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public UnicodeSymbolToCharConverter(ILinks<TLink> links, IConverter<TLink>
        ↳ numberToAddressConverter, ICriterionMatcher<TLink> unicodeSymbolCriterionMatcher) :
        ↳ base(links)
19         {
20             _numberToAddressConverter = numberToAddressConverter;
21             _unicodeSymbolCriterionMatcher = unicodeSymbolCriterionMatcher;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public char Convert(TLink source)
26         {
27             if (!_unicodeSymbolCriterionMatcher.IsMatched(source))
28             {
29                 throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
        ↳ not a unicode symbol.");
30             }
31             return _addressToCharConverter.Convert(_numberToAddressConverter.Convert(_links.GetS
        ↳ ource(source)));
32         }
33     }
34 }

```

1.135 ./csharp/Platform.Data.Doublets/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     public class UnicodeSymbolsListToUnicodeSequenceConverter<TLink> : LinksOperatorBase<TLink>,
11     ↪ IConverter<IList<TLink>, TLink>
12     {
13         private readonly ISequenceIndex<TLink> _index;
14         private readonly IConverter<IList<TLink>, TLink> _listToSequenceLinkConverter;
15         private readonly TLink _unicodeSequenceMarker;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public UnicodeSymbolsListToUnicodeSequenceConverter(ILinks<TLink> links,
19         ↪ ISequenceIndex<TLink> index, IConverter<IList<TLink>, TLink>
20         ↪ listToSequenceLinkConverter, TLink unicodeSequenceMarker) : base(links)
21         {
22             _index = index;
23             _listToSequenceLinkConverter = listToSequenceLinkConverter;
24             _unicodeSequenceMarker = unicodeSequenceMarker;
25         }
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         public UnicodeSymbolsListToUnicodeSequenceConverter(ILinks<TLink> links,
29         ↪ IConverter<IList<TLink>, TLink> listToSequenceLinkConverter, TLink
30         ↪ unicodeSequenceMarker)
31         : this(links, new Unindex<TLink>(), listToSequenceLinkConverter,
32         ↪ unicodeSequenceMarker) { }
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public TLink Convert(IList<TLink> list)
36         {
37             _index.Add(list);
38             var sequence = _listToSequenceLinkConverter.Convert(list);
39             return _links.GetOrCreate(sequence, _unicodeSequenceMarker);
40         }
41     }
42 }

```

1.136 ./csharp/Platform.Data.Doublets.Tests/GenericLinksTests.cs

```

1 using System;
2 using Xunit;
3 using Platform.Reflection;
4 using Platform.Memory;
5 using Platform.Scopes;
6 using Platform.Data.Doublets.Memory.United.Generic;
7
8 namespace Platform.Data.Doublets.Tests
9 {
10     public unsafe static class GenericLinksTests
11     {
12         [Fact]
13         public static void CRUDTest()
14         {
15             Using<byte>(links => links.TestCRUDOperations());
16             Using<ushort>(links => links.TestCRUDOperations());
17             Using<uint>(links => links.TestCRUDOperations());
18             Using<ulong>(links => links.TestCRUDOperations());
19         }
20
21         [Fact]
22         public static void RawNumbersCRUDTest()
23         {
24             Using<byte>(links => links.TestRawNumbersCRUDOperations());
25             Using<ushort>(links => links.TestRawNumbersCRUDOperations());
26             Using<uint>(links => links.TestRawNumbersCRUDOperations());
27             Using<ulong>(links => links.TestRawNumbersCRUDOperations());
28         }
29
30         [Fact]
31         public static void MultipleRandomCreationsAndDeletionsTest()
32         {
33             Using<byte>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
34             ↪ MultipleRandomCreationsAndDeletions(16)); // Cannot use more because current
35             ↪ implementation of tree cuts out 5 bits from the address space.
36             Using<ushort>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Te
37             ↪ stMultipleRandomCreationsAndDeletions(100));
38             Using<uint>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
39             ↪ MultipleRandomCreationsAndDeletions(100));
40         }
41     }
42 }

```

```

36         Using<ulong>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
        ↪ tMultipleRandomCreationsAndDeletions(100));
37     }
38
39     private static void Using<TLink>(Action<ILinks<TLink>> action)
40     {
41         using (var scope = new Scope<Types<HeapResizableDirectMemory,
        ↪ UnitedMemoryLinks<TLink>>>())
42         {
43             action(scope.Use<ILinks<TLink>>());
44         }
45     }
46 }
47 }

```

1.137 ./csharp/Platform.Data.Doublets.Tests/ILinksExtensionsTests.cs

```

1  using Xunit;
2
3  namespace Platform.Data.Doublets.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 }

```

1.138 ./csharp/Platform.Data.Doublets.Tests/LinksConstantsTests.cs

```

1  using Xunit;
2
3  namespace Platform.Data.Doublets.Tests
4  {
5      public static class LinksConstantsTests
6      {
7          [Fact]
8          public static void ExternalReferencesTest()
9          {
10             LinksConstants<ulong> constants = new LinksConstants<ulong>((1, long.MaxValue),
        ↪ (long.MaxValue + 1UL, ulong.MaxValue));
11
12             //var minimum = new Hybrid<ulong>(0, isExternal: true);
13             var minimum = new Hybrid<ulong>(1, isExternal: true);
14             var maximum = new Hybrid<ulong>(long.MaxValue, isExternal: true);
15
16             Assert.True(constants.IsExternalReference(minimum));
17             Assert.True(constants.IsExternalReference(maximum));
18         }
19     }
20 }

```

1.139 ./csharp/Platform.Data.Doublets.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.Doubllets.Memory;
21
22 namespace Platform.Data.Doubllets.Tests
23 {
24     public static class OptimalVariantSequenceTests
25     {
26         private static readonly string _sequenceExample = "зеленела зелёная зелень";
27         private static readonly string _loremIpsumExample = @"Lorem ipsum dolor sit amet,
        ↳ consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore
        ↳ magna aliqua.
28 Facilisi nullam vehicula ipsum a arcu cursus vitae congue mauris.
29 Et malesuada fames ac turpis egestas sed.
30 Eget velit aliquet sagittis id consectetur purus.
31 Dignissim cras tincidunt lobortis feugiat vivamus.
32 Vitae aliquet nec ullamcorper sit.
33 Lectus quam id leo in vitae.
34 Tortor dignissim convallis aenean et tortor at risus viverra adipiscing.
35 Sed risus ultricies tristique nulla aliquet enim tortor at auctor.
36 Integer eget aliquet nibh praesent tristique.
37 Vitae congue eu consequat ac felis donec et odio.
38 Tristique et egestas quis ipsum suspendisse.
39 Suspendisse potenti nullam ac tortor vitae purus faucibus ornare.
40 Nulla facilisi etiam dignissim diam quis enim lobortis scelerisque.
41 Imperdiet proin fermentum leo vel orci.
42 In ante metus dictum at tempor commodo.
43 Nisi lacus sed viverra tellus in.
44 Quam vulputate dignissim suspendisse in.
45 Elit scelerisque mauris pellentesque pulvinar pellentesque habitant morbi tristique senectus.
46 Gravida cum sociis natoque penatibus et magnis dis parturient.
47 Risus quis varius quam quisque id diam.
48 Congue nisi vitae suscipit tellus mauris a diam maecenas.
49 Eget nunc scelerisque viverra mauris in aliquam sem fringilla.
50 Pharetra vel turpis nunc eget lorem dolor sed viverra.
51 Mattis pellentesque id nibh tortor id aliquet.
52 Purus non enim praesent elementum facilisis leo vel.
53 Etiam sit amet nisl purus in mollis nunc sed.
54 Tortor at auctor urna nunc id cursus metus aliquam.
55 Volutpat odio facilisis mauris sit amet.
56 Turpis egestas pretium aenean pharetra magna ac placerat.
57 Fermentum dui faucibus in ornare quam viverra orci sagittis eu.
58 Porttitor leo a diam sollicitudin tempor id eu.
59 Volutpat sed cras ornare arcu dui.
60 Ut aliquam purus sit amet luctus venenatis lectus magna.
61 Aliquet risus feugiat in ante metus dictum at.
62 Mattis nunc sed blandit libero.
63 Elit pellentesque habitant morbi tristique senectus et netus.
64 Nibh sit amet commodo nulla facilisi nullam vehicula ipsum a.
65 Enim sit amet venenatis urna cursus eget nunc scelerisque viverra.
66 Amet venenatis urna cursus eget nunc scelerisque viverra mauris in.
67 Diam donec adipiscing tristique risus nec feugiat.
68 Pulvinar mattis nunc sed blandit libero volutpat.
69 Cras fermentum odio eu feugiat pretium nibh ipsum.
70 In nulla posuere sollicitudin aliquam ultrices sagittis orci a.
71 Mauris pellentesque pulvinar pellentesque habitant morbi tristique senectus et.
72 A iaculis at erat pellentesque.
73 Morbi blandit cursus risus at ultrices mi tempus imperdiet nulla.
74 Eget lorem dolor sed viverra ipsum nunc.
75 Leo a diam sollicitudin tempor id eu.
76 Interdum consectetur libero id faucibus nisl tincidunt eget nullam non.";
77
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);

```

```

98     var frequencyPropertyOperator = new PropertyOperator<ulong>(links,
99         ↪ frequencyPropertyMarker, frequencyMarker);
100    var index = new FrequencyIncrementingSequenceIndex<ulong>(links,
101        ↪ frequencyPropertyOperator, frequencyIncrementer);
102    var linkToItsFrequencyNumberConverter = new
103        ↪ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
104        ↪ unaryNumberToAddressConverter);
105    var sequenceToItsLocalElementLevelsConverter = new
106        ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
107        ↪ linkToItsFrequencyNumberConverter);
108    var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
109        ↪ sequenceToItsLocalElementLevelsConverter);
110
111    var sequences = new Sequences.Sequences(links, new SequencesOptions<ulong>() {
112        ↪ Walker = new LeveledSequenceWalker<ulong>(links) });
113
114    ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
115        ↪ index, optimalVariantConverter);
116    }
117 }
118
119 [Fact]
120 public static void DictionaryBasedFrequencyStoredOptimalVariantSequenceTest()
121 {
122     using (var scope = new TempLinksTestScope(useSequences: false))
123     {
124         var links = scope.Links;
125
126         links.UseUnicode();
127
128         var sequence = UnicodeMap.FromStringToLinkArray(_sequenceExample);
129
130         var totalSequenceSymbolFrequencyCounter = new
131             ↪ TotalSequenceSymbolFrequencyCounter<ulong>(links);
132
133         var linkFrequenciesCache = new LinkFrequenciesCache<ulong>(links,
134             ↪ totalSequenceSymbolFrequencyCounter);
135
136         var index = new
137             ↪ CachedFrequencyIncrementingSequenceIndex<ulong>(linkFrequenciesCache);
138         var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache);
139
140         var sequenceToItsLocalElementLevelsConverter = new
141             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
142             ↪ linkToItsFrequencyNumberConverter);
143         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
144             ↪ sequenceToItsLocalElementLevelsConverter);
145
146         var sequences = new Sequences.Sequences(links, new SequencesOptions<ulong>() {
147             ↪ Walker = new LeveledSequenceWalker<ulong>(links) });
148
149         ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
150             ↪ index, optimalVariantConverter);
151     }
152 }
153
154 private static void ExecuteTest(Sequences.Sequences sequences, ulong[] sequence,
155     ↪ SequenceToItsLocalElementLevelsConverter<ulong>
156     ↪ sequenceToItsLocalElementLevelsConverter, ISequenceIndex<ulong> index,
157     ↪ OptimalVariantConverter<ulong> optimalVariantConverter)
158 {
159     index.Add(sequence);
160
161     var optimalVariant = optimalVariantConverter.Convert(sequence);
162
163     var readSequence1 = sequences.ToList(optimalVariant);
164
165     Assert.True(sequence.SequenceEqual(readSequence1));
166 }
167
168 [Fact]
169 public static void SavedSequencesOptimizationTest()
170 {
171     LinksConstants<ulong> constants = new LinksConstants<ulong>((1, long.MaxValue),
172         ↪ (long.MaxValue + 1UL, ulong.MaxValue));
173
174     using (var memory = new HeapResizableDirectMemory())

```

```

154 using (var disposableLinks = new UInt64UnitedMemoryLinks(memory,
    ↳ UInt64UnitedMemoryLinks.DefaultLinksSizeStep, constants, IndexTreeType.Default))
155 {
156     var links = new UInt64Links(disposableLinks);
157
158     var root = links.CreatePoint();
159
160     //var numberToAddressConverter = new RawNumberToAddressConverter<ulong>();
161     var addressToNumberConverter = new AddressToRawNumberConverter<ulong>();
162
163     var unicodeSymbolMarker = links.GetOrCreate(root,
    ↳ addressToNumberConverter.Convert(1));
164     var unicodeSequenceMarker = links.GetOrCreate(root,
    ↳ addressToNumberConverter.Convert(2));
165
166     var totalSequenceSymbolFrequencyCounter = new
    ↳ TotalSequenceSymbolFrequencyCounter<ulong>(links);
167     var linkFrequenciesCache = new LinkFrequenciesCache<ulong>(links,
    ↳ totalSequenceSymbolFrequencyCounter);
168     var index = new
    ↳ CachedFrequencyIncrementingSequenceIndex<ulong>(linkFrequenciesCache);
169     var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFreque
    ↳ ncyNumberConverter<ulong>(linkFrequenciesCache);
170     var sequenceToItsLocalElementLevelsConverter = new
    ↳ SequenceToItsLocalElementLevelsConverter<ulong>(links,
    ↳ linkToItsFrequencyNumberConverter);
171     var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
    ↳ sequenceToItsLocalElementLevelsConverter);
172
173     var walker = new RightSequenceWalker<ulong>(links, new DefaultStack<ulong>(),
    ↳ (link) => constants.IsExternalReference(link) || links.IsPartialPoint(link));
174
175     var unicodeSequencesOptions = new SequencesOptions<ulong>()
176     {
177         UseSequenceMarker = true,
178         SequenceMarkerLink = unicodeSequenceMarker,
179         UseIndex = true,
180         Index = index,
181         LinksToSequenceConverter = optimalVariantConverter,
182         Walker = walker,
183         UseGarbageCollection = true
184     };
185
186     var unicodeSequences = new Sequences.Sequences(new
    ↳ SynchronizedLinks<ulong>(links), unicodeSequencesOptions);
187
188     // Create some sequences
189     var strings = _loremIpsumExample.Split(new[] { '\n', '\r' },
    ↳ StringSplitOptions.RemoveEmptyEntries);
190     var arrays = strings.Select(x => x.Select(y =>
    ↳ 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 }
212 }

```

1.140 ./csharp/Platform.Data.Doublets.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.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.Sequences(links, new SequencesOptions

```

1.141 ./csharp/Platform.Data.Doublets.Tests/ResizableDirectMemoryLinksTests.cs

```

1 using System.IO;
2 using Xunit;
3 using Platform.Singletons;
4 using Platform.Memory;
5 using Platform.Data.Doublets.Memory.United.Specific;
6
7 namespace Platform.Data.Doublets.Tests
8 {
9     public static class ResizableDirectMemoryLinksTests
10     {
11         private static readonly LinksConstants

```

```

17         using (var memoryAdapter = new UInt64UnitedMemoryLinks(tempFilename))
18         {
19             memoryAdapter.TestBasicMemoryOperations();
20         }
21         File.Delete(tempFilename);
22     }
23
24     [Fact]
25     public static void BasicHeapMemoryTest()
26     {
27         using (var memory = new
28             ↪ HeapResizableDirectMemory(UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
29         using (var memoryAdapter = new UInt64UnitedMemoryLinks(memory,
30             ↪ UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
31         {
32             memoryAdapter.TestBasicMemoryOperations();
33         }
34     }
35
36     private static void TestBasicMemoryOperations(this ILinks<ulong> memoryAdapter)
37     {
38         var link = memoryAdapter.Create();
39         memoryAdapter.Delete(link);
40     }
41
42     [Fact]
43     public static void NonexistentReferencesHeapMemoryTest()
44     {
45         using (var memory = new
46             ↪ HeapResizableDirectMemory(UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
47         using (var memoryAdapter = new UInt64UnitedMemoryLinks(memory,
48             ↪ UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
49         {
50             memoryAdapter.TestNonexistentReferences();
51         }
52     }
53
54     private static void TestNonexistentReferences(this ILinks<ulong> memoryAdapter)
55     {
56         var link = memoryAdapter.Create();
57         memoryAdapter.Update(link, ulong.MaxValue, ulong.MaxValue);
58         var resultLink = _constants.Null;
59         memoryAdapter.Each(foundLink =>
60         {
61             resultLink = foundLink[_constants.IndexPart];
62             return _constants.Break;
63         }, _constants.Any, ulong.MaxValue, ulong.MaxValue);
64         Assert.True(resultLink == link);
65         Assert.True(memoryAdapter.Count(ulong.MaxValue) == 0);
66         memoryAdapter.Delete(link);
67     }
68 }

```

1.142 ./csharp/Platform.Data.Doublets.Tests/ScopeTests.cs

```

1  using Xunit;
2  using Platform.Scopes;
3  using Platform.Memory;
4  using Platform.Data.Doublets.Decorators;
5  using Platform.Reflection;
6  using Platform.Data.Doublets.Memory.United.Generic;
7  using Platform.Data.Doublets.Memory.United.Specific;
8
9  namespace Platform.Data.Doublets.Tests
10 {
11     public static class ScopeTests
12     {
13         [Fact]
14         public static void SingleDependencyTest()
15         {
16             using (var scope = new Scope())
17             {
18                 scope.IncludeAssemblyOf<IMemory>();
19                 var instance = scope.Use<IDirectMemory>();
20                 Assert.IsType<HeapResizableDirectMemory>(instance);
21             }
22         }
23
24         [Fact]

```

```

25     public static void CascadeDependencyTest()
26     {
27         using (var scope = new Scope())
28         {
29             scope.Include<TemporaryFileMappedResizableDirectMemory>();
30             scope.Include<UInt64UnitedMemoryLinks>();
31             var instance = scope.Use<ILinks<ulong>>();
32             Assert.IsType<UInt64UnitedMemoryLinks>(instance);
33         }
34     }
35
36     [Fact]
37     public static void FullAutoResolutionTest()
38     {
39         using (var scope = new Scope(autoInclude: true, autoExplore: true))
40         {
41             var instance = scope.Use<UInt64Links>();
42             Assert.IsType<UInt64Links>(instance);
43         }
44     }
45
46     [Fact]
47     public static void TypeParametersTest()
48     {
49         using (var scope = new Scope<Types<HeapResizableDirectMemory,
50             ↪ UnitedMemoryLinks<ulong>>>())
51         {
52             var links = scope.Use<ILinks<ulong>>();
53             Assert.IsType<UnitedMemoryLinks<ulong>>(links);
54         }
55     }
56 }

```

1.143 ./csharp/Platform.Data.Doublets.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.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         }
47     }
48 }

```



```

45     var sw1 = Stopwatch.StartNew();
46     var results1 = sequences.CreateAllVariants1(sequence); sw1.Stop();
47
48     var sw2 = Stopwatch.StartNew();
49     var results2 = sequences.CreateAllVariants2(sequence); sw2.Stop();
50
51     Assert.True(results1.Count > results2.Length);
52     Assert.True(sw1.Elapsed > sw2.Elapsed);
53
54     for (var i = 0; i < sequenceLength; i++)
55     {
56         links.Delete(sequence[i]);
57     }
58
59     Assert.True(links.Count() == 0);
60 }
61 }
62
63 // [Fact]
64 // public void CUDTest()
65 // {
66 //     var tempFilename = Path.GetTempFileName();
67
68 //     const long sequenceLength = 8;
69
70 //     const ulong itself = LinksConstants.Itself;
71
72 //     using (var memoryAdapter = new ResizableDirectMemoryLinks(tempFilename,
73 ↪ DefaultLinksSizeStep))
74 //     using (var links = new Links(memoryAdapter))
75 //     {
76 //         var sequence = new ulong[sequenceLength];
77 //         for (var i = 0; i < sequenceLength; i++)
78 //             sequence[i] = links.Create(itself, itself);
79
80 //         SequencesOptions o = new SequencesOptions();
81
82 //         // TODO: Из числа в bool значения o.UseSequenceMarker = ((value & 1) != 0)
83 //         o.
84
85 //         var sequences = new Sequences(links);
86
87 //         var sw1 = Stopwatch.StartNew();
88 //         var results1 = sequences.CreateAllVariants1(sequence); sw1.Stop();
89
90 //         var sw2 = Stopwatch.StartNew();
91 //         var results2 = sequences.CreateAllVariants2(sequence); sw2.Stop();
92
93 //         Assert.True(results1.Count > results2.Length);
94 //         Assert.True(sw1.Elapsed > sw2.Elapsed);
95
96 //         for (var i = 0; i < sequenceLength; i++)
97 //             links.Delete(sequence[i]);
98 //     }
99
100 //     File.Delete(tempFilename);
101 // }
102
103 [Fact]
104 public static void AllVariantsSearchTest()
105 {
106     const long sequenceLength = 8;
107
108     using (var scope = new TempLinksTestScope(useSequences: true))
109     {
110         var links = scope.Links;
111         var sequences = scope.Sequences;
112
113         var sequence = new ulong[sequenceLength];
114         for (var i = 0; i < sequenceLength; i++)
115         {
116             sequence[i] = links.Create();
117         }
118
119         var createResults = sequences.CreateAllVariants2(sequence).Distinct().ToArray();
120
121         // for (int i = 0; i < createResults.Length; i++)
122         //     sequences.Create(createResults[i]);
123
124         var sw0 = Stopwatch.StartNew();

```

```

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

```

```

277     var balancedVariant = balancedVariantConverter.Convert(sequence);
278
279     var partialSequence = new ulong[sequenceLength - 2];
280
281     Array.Copy(sequence, 1, partialSequence, 0, (int)sequenceLength - 2);
282
283     var sw1 = Stopwatch.StartNew();
284     var searchResults1 =
285         ↪ sequences.GetAllPartiallyMatchingSequences0(partialSequence); sw1.Stop();
286
287     var sw2 = Stopwatch.StartNew();
288     var searchResults2 =
289         ↪ sequences.GetAllPartiallyMatchingSequences1(partialSequence); sw2.Stop();
290
291     Assert.True(searchResults1.Count == 1 && balancedVariant == searchResults1[0]);
292
293     Assert.True(searchResults2.Count == 1 && balancedVariant ==
294         ↪ searchResults2.First());
295
296     for (var i = 0; i < sequenceLength; i++)
297     {
298         links.Delete(sequence[i]);
299     }
300 }
301 [Fact(Skip = "Correct implementation is pending")]
302 public static void PatternMatchTest()
303 {
304     var zeroOrMany = Sequences.Sequences.ZeroOrMany;
305
306     using (var scope = new TempLinksTestScope(useSequences: true))
307     {
308         var links = scope.Links;
309         var sequences = scope.Sequences;
310
311         var e1 = links.Create();
312         var e2 = links.Create();
313
314         var sequence = new[]
315         {
316             e1, e2, e1, e2 // mama / papa
317         };
318
319         var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
320
321         var balancedVariant = balancedVariantConverter.Convert(sequence);
322
323         // 1: [1]
324         // 2: [2]
325         // 3: [1,2]
326         // 4: [1,2,1,2]
327
328         var doublet = links.GetSource(balancedVariant);
329
330         var matchedSequences1 = sequences.MatchPattern(e2, e1, zeroOrMany);
331
332         Assert.True(matchedSequences1.Count == 0);
333
334         var matchedSequences2 = sequences.MatchPattern(zeroOrMany, e2, e1);
335
336         Assert.True(matchedSequences2.Count == 0);
337
338         var matchedSequences3 = sequences.MatchPattern(e1, zeroOrMany, e1);
339
340         Assert.True(matchedSequences3.Count == 0);
341
342         var matchedSequences4 = sequences.MatchPattern(e1, zeroOrMany, e2);
343
344         Assert.Contains(doublet, matchedSequences4);
345         Assert.Contains(balancedVariant, matchedSequences4);
346
347         for (var i = 0; i < sequence.Length; i++)
348         {
349             links.Delete(sequence[i]);
350         }
351     }
352 }
353

```

```

354 [Fact]
355 public static void IndexTest()
356 {
357     using (var scope = new TempLinksTestScope(new SequencesOptions<ulong> { UseIndex =
↪ true }, useSequences: true))
358     {
359         var links = scope.Links;
360         var sequences = scope.Sequences;
361         var index = sequences.Options.Index;
362
363         var e1 = links.Create();
364         var e2 = links.Create();
365
366         var sequence = new[]
367         {
368             e1, e2, e1, e2 // mama / papa
369         };
370
371         Assert.False(index.MightContain(sequence));
372
373         index.Add(sequence);
374
375         Assert.True(index.MightContain(sequence));
376     }
377 }
378
379 /// <summary>Imported from https://raw.githubusercontent.com/Konard/LinksPlatform/%
↪ D0%9E-%D1%82%D0%BE%D0%BC%2C-%D0%BA%D0%B0%D0%BA-%D0%B2%D1%81%D1%91-%D0%BD%D0%B0%D1%87
↪ %D0%B8%D0%BD%D0%B0%D0%BB%D0%BE%D1%81%D1%8C.md</summary>
380 private static readonly string _exampleText =
381     @"([english
↪ version](https://github.com/Konard/LinksPlatform/wiki/About-the-beginning))

```

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

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

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

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

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

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

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

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

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

402
403 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?

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

406
407 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?

408
409 `[[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)`

410
411 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?

412
413 `[[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)`

414
415 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?

416
417 `[[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)`

418
419 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?

420
421 `[[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)`

422
423 На один уровень внутрь (вниз)? Или на один уровень во вне (вверх)? Или это можно назвать шагом
→ рекурсии или фрактала?

424
425 `[[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)`

426
427 Последовательность? Массив? Список? Множество? Объект? Таблица? Элементы? Цвета? Символы? Буквы?
→ Слово? Цифры? Число? Алфавит? Дерево? Сеть? Граф? Гиперграф?

428
429 `[[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)`

430
431 ...

432
433 `[[анимация](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/intro-anim`
→ `ation-500.gif`
→ `"анимация")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/intro`
→ `-animation-500.gif)";`

434

```

435     private static readonly string _exampleLoremIpsumText =
436         @"Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor
        ↳ incididunt ut labore et dolore magna aliqua.
437     Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo
        ↳ consequat.";
438
439     [Fact]
440     public static void CompressionTest()
441     {
442         using (var scope = new TempLinksTestScope(useSequences: true))
443         {
444             var links = scope.Links;
445             var sequences = scope.Sequences;
446
447             var e1 = links.Create();
448             var e2 = links.Create();
449
450             var sequence = new[]
451             {
452                 e1, e2, e1, e2 // mama / papa / template [(m/p), a] { [1] [2] [1] [2] }
453             };
454
455             var balancedVariantConverter = new BalancedVariantConverter<ulong>(links.Unsync);
456             var totalSequenceSymbolFrequencyCounter = new
457                 ↳ TotalSequenceSymbolFrequencyCounter<ulong>(links.Unsync);
458             var doubletFrequenciesCache = new LinkFrequenciesCache<ulong>(links.Unsync,
459                 ↳ totalSequenceSymbolFrequencyCounter);
460             var compressingConverter = new CompressingConverter<ulong>(links.Unsync,
461                 ↳ balancedVariantConverter, doubletFrequenciesCache);
462
463             var compressedVariant = compressingConverter.Convert(sequence);
464
465             // 1: [1]          (1->1) point
466             // 2: [2]          (2->2) point
467             // 3: [1,2]        (1->2) doublet
468             // 4: [1,2,1,2]    (3->3) doublet
469
470             Assert.True(links.GetSource(links.GetSource(compressedVariant)) == sequence[0]);
471             Assert.True(links.GetTarget(links.GetSource(compressedVariant)) == sequence[1]);
472             Assert.True(links.GetSource(links.GetTarget(compressedVariant)) == sequence[2]);
473             Assert.True(links.GetTarget(links.GetTarget(compressedVariant)) == sequence[3]);
474
475             var source = _constants.SourcePart;
476             var target = _constants.TargetPart;
477
478             Assert.True(links.GetByKeys(compressedVariant, source, source) == sequence[0]);
479             Assert.True(links.GetByKeys(compressedVariant, source, target) == sequence[1]);
480             Assert.True(links.GetByKeys(compressedVariant, target, source) == sequence[2]);
481             Assert.True(links.GetByKeys(compressedVariant, target, target) == sequence[3]);
482
483             // 4 - length of sequence
484             Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 0)
485                 ↳ == sequence[0]);
486             Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 1)
487                 ↳ == sequence[1]);
488             Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 2)
489                 ↳ == sequence[2]);
490             Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 3)
491                 ↳ == sequence[3]);
492         }
493     }
494
495     [Fact]
496     public static void CompressionEfficiencyTest()
497     {
498         var strings = _exampleLoremIpsumText.Split(new[] { '\n', '\r' },
499             ↳ StringSplitOptions.RemoveEmptyEntries);
500         var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
501         var totalCharacters = arrays.Select(x => x.Length).Sum();
502
503         using (var scope1 = new TempLinksTestScope(useSequences: true))
504         using (var scope2 = new TempLinksTestScope(useSequences: true))
505         using (var scope3 = new TempLinksTestScope(useSequences: true))
506         {
507             scope1.Links.Unsync.UseUnicode();
508             scope2.Links.Unsync.UseUnicode();
509             scope3.Links.Unsync.UseUnicode();
510         }
511     }

```

```

503     var balancedVariantConverter1 = new
504         ↳ BalancedVariantConverter<ulong>(scope1.Links.Unsync);
505     var totalSequenceSymbolFrequencyCounter = new
506         ↳ TotalSequenceSymbolFrequencyCounter<ulong>(scope1.Links.Unsync);
507     var linkFrequenciesCache1 = new LinkFrequenciesCache<ulong>(scope1.Links.Unsync,
508         ↳ totalSequenceSymbolFrequencyCounter);
509     var compressor1 = new CompressingConverter<ulong>(scope1.Links.Unsync,
510         ↳ balancedVariantConverter1, linkFrequenciesCache1,
511         ↳ doInitialFrequenciesIncrement: false);
512
513     //var compressor2 = scope2.Sequences;
514     var compressor3 = scope3.Sequences;
515
516     var constants = Default<LinksConstants<ulong>>.Instance;
517
518     var sequences = compressor3;
519     //var meaningRoot = links.CreatePoint();
520     //var unaryOne = links.CreateAndUpdate(meaningRoot, constants.Itself);
521     //var frequencyMarker = links.CreateAndUpdate(meaningRoot, constants.Itself);
522     //var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot,
523         ↳ constants.Itself);
524
525     //var unaryNumberToAddressConverter = new
526         ↳ UnaryNumberToAddressAddOperationConverter<ulong>(links, unaryOne);
527     //var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links,
528         ↳ unaryOne);
529     //var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
530         ↳ frequencyMarker, unaryOne, unaryNumberIncrementer);
531     //var frequencyPropertyOperator = new FrequencyPropertyOperator<ulong>(links,
532         ↳ frequencyPropertyMarker, frequencyMarker);
533     //var linkFrequencyIncrementer = new LinkFrequencyIncrementer<ulong>(links,
534         ↳ frequencyPropertyOperator, frequencyIncrementer);
535     //var linkToItsFrequencyNumberConverter = new
536         ↳ LinkToItsFrequencyNumberConveter<ulong>(links, frequencyPropertyOperator,
537         ↳ unaryNumberToAddressConverter);
538
539     var linkFrequenciesCache3 = new LinkFrequenciesCache<ulong>(scope3.Links.Unsync,
540         ↳ totalSequenceSymbolFrequencyCounter);
541
542     var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache3);
543
544     var sequenceToItsLocalElementLevelsConverter = new
545         ↳ SequenceToItsLocalElementLevelsConverter<ulong>(scope3.Links.Unsync,
546         ↳ linkToItsFrequencyNumberConverter);
547     var optimalVariantConverter = new
548         ↳ OptimalVariantConverter<ulong>(scope3.Links.Unsync,
549         ↳ sequenceToItsLocalElementLevelsConverter);
550
551     var compressed1 = new ulong[arrays.Length];
552     var compressed2 = new ulong[arrays.Length];
553     var compressed3 = new ulong[arrays.Length];
554
555     var START = 0;
556     var END = arrays.Length;
557
558     //for (int i = START; i < END; i++)
559     //    linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
560
561     var initialCount1 = scope2.Links.Unsync.Count();
562
563     var sw1 = Stopwatch.StartNew();
564
565     for (int i = START; i < END; i++)
566     {
567         linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
568         compressed1[i] = compressor1.Convert(arrays[i]);
569     }
570
571     var elapsed1 = sw1.Elapsed;
572
573     var balancedVariantConverter2 = new
574         ↳ BalancedVariantConverter<ulong>(scope2.Links.Unsync);
575
576     var initialCount2 = scope2.Links.Unsync.Count();
577
578     var sw2 = Stopwatch.StartNew();

```



```

561 for (int i = START; i < END; i++)
562 {
563     compressed2[i] = balancedVariantConverter2.Convert(arrays[i]);
564 }
565
566 var elapsed2 = sw2.Elapsed;
567
568 for (int i = START; i < END; i++)
569 {
570     linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
571 }
572
573 var initialCount3 = scope3.Links.Unsync.Count();
574
575 var sw3 = Stopwatch.StartNew();
576
577 for (int i = START; i < END; i++)
578 {
579     //linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
580     compressed3[i] = optimalVariantConverter.Convert(arrays[i]);
581 }
582
583 var elapsed3 = sw3.Elapsed;
584
585 Console.WriteLine($"Compressor: {elapsed1}, Balanced variant: {elapsed2},
586     ↳ Optimal variant: {elapsed3}");
587
588 // Assert.True(elapsed1 > elapsed2);
589
590 // Checks
591 for (int i = START; i < END; i++)
592 {
593     var sequence1 = compressed1[i];
594     var sequence2 = compressed2[i];
595     var sequence3 = compressed3[i];
596
597     var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
598         ↳ scope1.Links.Unsync);
599
600     var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
601         ↳ scope2.Links.Unsync);
602
603     var decompress3 = UnicodeMap.FromSequenceLinkToString(sequence3,
604         ↳ scope3.Links.Unsync);
605
606     var structure1 = scope1.Links.Unsync.FormatStructure(sequence1, link =>
607         ↳ link.IsPartialPoint());
608     var structure2 = scope2.Links.Unsync.FormatStructure(sequence2, link =>
609         ↳ link.IsPartialPoint());
610     var structure3 = scope3.Links.Unsync.FormatStructure(sequence3, link =>
611         ↳ link.IsPartialPoint());
612
613     //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
614     ↳ arrays[i].Length > 3)
615     //    Assert.False(structure1 == structure2);
616     //if (sequence3 != Constants.Null && sequence2 != Constants.Null &&
617     ↳ arrays[i].Length > 3)
618     //    Assert.False(structure3 == structure2);
619
620     Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
621     Assert.True(strings[i] == decompress3 && decompress3 == decompress2);
622 }
623
624 Assert.True((int)(scope1.Links.Unsync.Count() - initialCount1) <
625     ↳ totalCharacters);
626 Assert.True((int)(scope2.Links.Unsync.Count() - initialCount2) <
627     ↳ totalCharacters);
628 Assert.True((int)(scope3.Links.Unsync.Count() - initialCount3) <
629     ↳ totalCharacters);
630
631 Console.WriteLine($"{{(double)(scope1.Links.Unsync.Count() - initialCount1) /
632     ↳ totalCharacters}} | {{(double)(scope2.Links.Unsync.Count() - initialCount2) /
633     ↳ totalCharacters}} | {{(double)(scope3.Links.Unsync.Count() - initialCount3) /
634     ↳ totalCharacters}}");
635
636 Assert.True(scope1.Links.Unsync.Count() - initialCount1 <
637     ↳ scope2.Links.Unsync.Count() - initialCount2);

```

```

622     Assert.True(scope3.Links.Unsync.Count() - initialCount3 <
        ↳ scope2.Links.Unsync.Count() - initialCount2);
623
624     var duplicateProvider1 = new
        ↳ DuplicateSegmentsProvider<ulong>(scope1.Links.Unsync, scope1.Sequences);
625     var duplicateProvider2 = new
        ↳ DuplicateSegmentsProvider<ulong>(scope2.Links.Unsync, scope2.Sequences);
626     var duplicateProvider3 = new
        ↳ DuplicateSegmentsProvider<ulong>(scope3.Links.Unsync, scope3.Sequences);
627
628     var duplicateCounter1 = new DuplicateSegmentsCounter<ulong>(duplicateProvider1);
629     var duplicateCounter2 = new DuplicateSegmentsCounter<ulong>(duplicateProvider2);
630     var duplicateCounter3 = new DuplicateSegmentsCounter<ulong>(duplicateProvider3);
631
632     var duplicates1 = duplicateCounter1.Count();
633
634     ConsoleHelpers.Debug("-----");
635
636     var duplicates2 = duplicateCounter2.Count();
637
638     ConsoleHelpers.Debug("-----");
639
640     var duplicates3 = duplicateCounter3.Count();
641
642     Console.WriteLine($"{duplicates1} | {duplicates2} | {duplicates3}");
643
644     linkFrequenciesCache1.ValidateFrequencies();
645     linkFrequenciesCache3.ValidateFrequencies();
646 }
647 }
648
649 [Fact]
650 public static void CompressionStabilityTest()
651 {
652     // TODO: Fix bug (do a separate test)
653     //const ulong minNumbers = 0;
654     //const ulong maxNumbers = 1000;
655
656     const ulong minNumbers = 10000;
657     const ulong maxNumbers = 12500;
658
659     var strings = new List<string>();
660
661     for (ulong i = minNumbers; i < maxNumbers; i++)
662     {
663         strings.Add(i.ToString());
664     }
665
666     var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
667     var totalCharacters = arrays.Select(x => x.Length).Sum();
668
669     using (var scope1 = new TempLinksTestScope(useSequences: true, sequencesOptions: new
        ↳ SequencesOptions<ulong> { UseCompression = true,
        ↳ EnforceSingleSequenceVersionOnWriteBasedOnExisting = true }))
        using (var scope2 = new TempLinksTestScope(useSequences: true))
        {
670         scope1.Links.UseUnicode();
671         scope2.Links.UseUnicode();
672
673         //var compressor1 = new Compressor(scope1.Links.Unsync, scope1.Sequences);
674         var compressor1 = scope1.Sequences;
675         var compressor2 = scope2.Sequences;
676
677         var compressed1 = new ulong[arrays.Length];
678         var compressed2 = new ulong[arrays.Length];
679
680         var sw1 = Stopwatch.StartNew();
681
682         var START = 0;
683         var END = arrays.Length;
684
685         // Collisions proved (cannot be solved by max doublet comparison, no stable rule)
686         // Stability issue starts at 10001 or 11000
687         //for (int i = START; i < END; i++)
688         //{
689             var first = compressor1.Compress(arrays[i]);
690             var second = compressor1.Compress(arrays[i]);
691
692             if (first == second)
693                 compressed1[i] = first;
694         }
695

```

```

696 //     else
697 //     {
698 //         // TODO: Find a solution for this case
699 //     }
700 //}
701
702 for (int i = START; i < END; i++)
703 {
704     var first = compressor1.Create(arrays[i].ShiftRight());
705     var second = compressor1.Create(arrays[i].ShiftRight());
706
707     if (first == second)
708     {
709         compressed1[i] = first;
710     }
711     else
712     {
713         // TODO: Find a solution for this case
714     }
715 }
716
717 var elapsed1 = sw1.Elapsed;
718
719 var balancedVariantConverter = new BalancedVariantConverter<ulong>(scope2.Links);
720
721 var sw2 = Stopwatch.StartNew();
722
723 for (int i = START; i < END; i++)
724 {
725     var first = balancedVariantConverter.Convert(arrays[i]);
726     var second = balancedVariantConverter.Convert(arrays[i]);
727
728     if (first == second)
729     {
730         compressed2[i] = first;
731     }
732 }
733
734 var elapsed2 = sw2.Elapsed;
735
736 Debug.WriteLine($"Compressor: {elapsed1}, Balanced sequence creator:
737 ↪ {elapsed2}");
738
739 Assert.True(elapsed1 > elapsed2);
740
741 // Checks
742 for (int i = START; i < END; i++)
743 {
744     var sequence1 = compressed1[i];
745     var sequence2 = compressed2[i];
746
747     if (sequence1 != _constants.Null && sequence2 != _constants.Null)
748     {
749         var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
750 ↪ scope1.Links);
751
752         var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
753 ↪ scope2.Links);
754
755         //var structure1 = scope1.Links.FormatStructure(sequence1, link =>
756 ↪ link.IsPartialPoint());
757         //var structure2 = scope2.Links.FormatStructure(sequence2, link =>
758 ↪ link.IsPartialPoint());
759
760         //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
761 ↪ arrays[i].Length > 3)
762         //    Assert.False(structure1 == structure2);
763
764         Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
765     }
766 }
767
768 Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
769 Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
770
771 Debug.WriteLine($"{{(double)(scope1.Links.Count() - UnicodeMap.MapSize) /
772 ↪ totalCharacters}} | {{(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
773 ↪ totalCharacters}}");

```

```

767         Assert.True(scope1.Links.Count() <= scope2.Links.Count());
768
769         //compressor1.ValidateFrequencies();
770     }
771 }
772
773 [Fact]
774 public static void RandomNumbersCompressionQualityTest()
775 {
776     const ulong N = 500;
777
778     //const ulong minNumbers = 10000;
779     //const ulong maxNumbers = 20000;
780
781     //var strings = new List<string>();
782
783     //for (ulong i = 0; i < N; i++)
784     //    strings.Add(RandomHelpers.DefaultFactory.NextUInt64(minNumbers,
785     //        ↪ maxNumbers).ToString());
786
787     var strings = new List<string>();
788
789     for (ulong i = 0; i < N; i++)
790     {
791         strings.Add(RandomHelpers.Default.NextUInt64().ToString());
792     }
793
794     strings = strings.Distinct().ToList();
795
796     var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
797     var totalCharacters = arrays.Select(x => x.Length).Sum();
798
799     using (var scope1 = new TempLinksTestScope(useSequences: true, sequencesOptions: new
800     ↪ SequencesOptions<ulong> { UseCompression = true,
801     ↪ EnforceSingleSequenceVersionOnWriteBasedOnExisting = true }))
802     using (var scope2 = new TempLinksTestScope(useSequences: true))
803     {
804         scope1.Links.UseUnicode();
805         scope2.Links.UseUnicode();
806
807         var compressor1 = scope1.Sequences;
808         var compressor2 = scope2.Sequences;
809
810         var compressed1 = new ulong[arrays.Length];
811         var compressed2 = new ulong[arrays.Length];
812
813         var sw1 = Stopwatch.StartNew();
814
815         var START = 0;
816         var END = arrays.Length;
817
818         for (int i = START; i < END; i++)
819         {
820             compressed1[i] = compressor1.Create(arrays[i].ShiftRight());
821         }
822
823         var elapsed1 = sw1.Elapsed;
824
825         var balancedVariantConverter = new BalancedVariantConverter<ulong>(scope2.Links);
826
827         var sw2 = Stopwatch.StartNew();
828
829         for (int i = START; i < END; i++)
830         {
831             compressed2[i] = balancedVariantConverter.Convert(arrays[i]);
832         }
833
834         var elapsed2 = sw2.Elapsed;
835
836         Debug.WriteLine($"Compressor: {elapsed1}, Balanced sequence creator:
837         ↪ {elapsed2}");
838
839         Assert.True(elapsed1 > elapsed2);
840
841         // Checks
842         for (int i = START; i < END; i++)
843         {
844             var sequence1 = compressed1[i];
845             var sequence2 = compressed2[i];

```

```

843         if (sequence1 != _constants.Null && sequence2 != _constants.Null)
844         {
845             var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
846                 ↳ scope1.Links);
847
848             var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
849                 ↳ scope2.Links);
850
851             Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
852         }
853     }
854
855     Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
856     Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
857
858     Debug.WriteLine($"{{(double)(scope1.Links.Count() - UnicodeMap.MapSize) /
859         ↳ totalCharacters}} | {{(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
860         ↳ totalCharacters}}");
861
862     // Can be worse than balanced variant
863     //Assert.True(scope1.Links.Count() <= scope2.Links.Count());
864
865     //compressor1.ValidateFrequencies();
866 }
867
868 [Fact]
869 public static void AllTreeBreakDownAtSequencesCreationBugTest()
870 {
871     // Made out of AllPossibleConnectionsTest test.
872
873     //const long sequenceLength = 5; //100% bug
874     const long sequenceLength = 4; //100% bug
875     //const long sequenceLength = 3; //100% _no_bug (ok)
876
877     using (var scope = new TempLinksTestScope(useSequences: true))
878     {
879         var links = scope.Links;
880         var sequences = scope.Sequences;
881
882         var sequence = new ulong[sequenceLength];
883         for (var i = 0; i < sequenceLength; i++)
884         {
885             sequence[i] = links.Create();
886         }
887
888         var createResults = sequences.CreateAllVariants2(sequence);
889
890         Global.Trash = createResults;
891
892         for (var i = 0; i < sequenceLength; i++)
893         {
894             links.Delete(sequence[i]);
895         }
896     }
897 }
898
899 [Fact]
900 public static void AllPossibleConnectionsTest()
901 {
902     const long sequenceLength = 5;
903
904     using (var scope = new TempLinksTestScope(useSequences: true))
905     {
906         var links = scope.Links;
907         var sequences = scope.Sequences;
908
909         var sequence = new ulong[sequenceLength];
910         for (var i = 0; i < sequenceLength; i++)
911         {
912             sequence[i] = links.Create();
913         }
914
915         var createResults = sequences.CreateAllVariants2(sequence);
916         var reverseResults = sequences.CreateAllVariants2(sequence.Reverse().ToArray());
917
918         for (var i = 0; i < 1; i++)
919         {
920             var sw1 = Stopwatch.StartNew();

```

```

918         var searchResults1 = sequences.GetAllConnections(sequence); sw1.Stop();
919
920         var sw2 = Stopwatch.StartNew();
921         var searchResults2 = sequences.GetAllConnections1(sequence); sw2.Stop();
922
923         var sw3 = Stopwatch.StartNew();
924         var searchResults3 = sequences.GetAllConnections2(sequence); sw3.Stop();
925
926         var sw4 = Stopwatch.StartNew();
927         var searchResults4 = sequences.GetAllConnections3(sequence); sw4.Stop();
928
929         Global.Trash = searchResults3;
930         Global.Trash = searchResults4; //-V3008
931
932         var intersection1 = createResults.Intersect(searchResults1).ToList();
933         Assert.True(intersection1.Count == createResults.Length);
934
935         var intersection2 = reverseResults.Intersect(searchResults1).ToList();
936         Assert.True(intersection2.Count == reverseResults.Length);
937
938         var intersection0 = searchResults1.Intersect(searchResults2).ToList();
939         Assert.True(intersection0.Count == searchResults2.Count);
940
941         var intersection3 = searchResults2.Intersect(searchResults3).ToList();
942         Assert.True(intersection3.Count == searchResults3.Count);
943
944         var intersection4 = searchResults3.Intersect(searchResults4).ToList();
945         Assert.True(intersection4.Count == searchResults4.Count);
946     }
947
948     for (var i = 0; i < sequenceLength; i++)
949     {
950         links.Delete(sequence[i]);
951     }
952 }
953
954 [Fact(Skip = "Correct implementation is pending")]
955 public static void CalculateAllUsagesTest()
956 {
957     const long sequenceLength = 3;
958
959     using (var scope = new TempLinksTestScope(useSequences: true))
960     {
961         var links = scope.Links;
962         var sequences = scope.Sequences;
963
964         var sequence = new ulong[sequenceLength];
965         for (var i = 0; i < sequenceLength; i++)
966         {
967             sequence[i] = links.Create();
968         }
969
970         var createResults = sequences.CreateAllVariants2(sequence);
971
972         //var reverseResults =
973         ↪ sequences.CreateAllVariants2(sequence.Reverse().ToArray());
974
975         for (var i = 0; i < 1; i++)
976         {
977             var linksTotalUsages1 = new ulong[links.Count() + 1];
978
979             sequences.CalculateAllUsages(linksTotalUsages1);
980
981             var linksTotalUsages2 = new ulong[links.Count() + 1];
982
983             sequences.CalculateAllUsages2(linksTotalUsages2);
984
985             var intersection1 = linksTotalUsages1.Intersect(linksTotalUsages2).ToList();
986             Assert.True(intersection1.Count == linksTotalUsages2.Length);
987         }
988
989         for (var i = 0; i < sequenceLength; i++)
990         {
991             links.Delete(sequence[i]);
992         }
993     }
994 }
995 }
996 }

```

1.144 ./csharp/Platform.Data.Doublets.Tests/SplitMemoryGenericLinksTests.cs

```

1  using System;
2  using Xunit;
3  using Platform.Memory;
4  using Platform.Data.Doublets.Memory.Split.Generic;
5
6  namespace Platform.Data.Doublets.Tests
7  {
8      public unsafe static class SplitMemoryGenericLinksTests
9      {
10         [Fact]
11         public static void CRUDTest()
12         {
13             Using<byte>(links => links.TestCRUDOperations());
14             Using<ushort>(links => links.TestCRUDOperations());
15             Using<uint>(links => links.TestCRUDOperations());
16             Using<ulong>(links => links.TestCRUDOperations());
17         }
18
19         [Fact]
20         public static void RawNumbersCRUDTest()
21         {
22             UsingWithExternalReferences<byte>(links => links.TestRawNumbersCRUDOperations());
23             UsingWithExternalReferences<ushort>(links => links.TestRawNumbersCRUDOperations());
24             UsingWithExternalReferences<uint>(links => links.TestRawNumbersCRUDOperations());
25             UsingWithExternalReferences<ulong>(links => links.TestRawNumbersCRUDOperations());
26         }
27
28         [Fact]
29         public static void MultipleRandomCreationsAndDeletionsTest()
30         {
31             Using<byte>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
32             ↪ MultipleRandomCreationsAndDeletions(16)); // Cannot use more because current
33             ↪ implementation of tree cuts out 5 bits from the address space.
34             Using<ushort>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Te
35             ↪ stMultipleRandomCreationsAndDeletions(100));
36             Using<uint>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
37             ↪ MultipleRandomCreationsAndDeletions(100));
38             Using<ulong>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Tes
39             ↪ tMultipleRandomCreationsAndDeletions(100));
40         }
41
42         private static void Using<TLink>(Action<ILinks<TLink>> action)
43         {
44             using (var dataMemory = new HeapResizableDirectMemory())
45             using (var indexMemory = new HeapResizableDirectMemory())
46             using (var memory = new SplitMemoryLinks<TLink>(dataMemory, indexMemory))
47             {
48                 action(memory);
49             }
50         }
51
52         private static void UsingWithExternalReferences<TLink>(Action<ILinks<TLink>> action)
53         {
54             var constants = new LinksConstants<TLink>(enableExternalReferencesSupport: true);
55             using (var dataMemory = new HeapResizableDirectMemory())
56             using (var indexMemory = new HeapResizableDirectMemory())
57             using (var memory = new SplitMemoryLinks<TLink>(dataMemory, indexMemory,
58             ↪ SplitMemoryLinks<TLink>.DefaultLinksSizeStep, constants))
59             {
60                 action(memory);
61             }
62         }
63     }
64 }

```

1.145 ./csharp/Platform.Data.Doublets.Tests/SplitMemoryUInt32LinksTests.cs

```

1  using System;
2  using Xunit;
3  using Platform.Memory;
4  using Platform.Data.Doublets.Memory.Split.Specific;
5  using TLink = System.UInt32;
6
7  namespace Platform.Data.Doublets.Tests
8  {
9      public unsafe static class SplitMemoryUInt32LinksTests
10     {
11         [Fact]
12         public static void CRUDTest()

```

```

13     {
14         Using(links => links.TestCRUDOperations());
15     }
16
17     [Fact]
18     public static void RawNumbersCRUDTest()
19     {
20         UsingWithExternalReferences(links => links.TestRawNumbersCRUDOperations());
21     }
22
23     [Fact]
24     public static void MultipleRandomCreationsAndDeletionsTest()
25     {
26         Using(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().TestMultipleRandomCreationsAndDeletions(100));
27     }
28
29     private static void Using(Action<ILinks<TLink>> action)
30     {
31         using (var dataMemory = new HeapResizableDirectMemory())
32         using (var indexMemory = new HeapResizableDirectMemory())
33         using (var memory = new UInt32SplitMemoryLinks(dataMemory, indexMemory))
34         {
35             action(memory);
36         }
37     }
38
39     private static void UsingWithExternalReferences(Action<ILinks<TLink>> action)
40     {
41         var constants = new LinksConstants<TLink>(enableExternalReferencesSupport: true);
42         using (var dataMemory = new HeapResizableDirectMemory())
43         using (var indexMemory = new HeapResizableDirectMemory())
44         using (var memory = new UInt32SplitMemoryLinks(dataMemory, indexMemory,
45             ↪ UInt32SplitMemoryLinks.DefaultLinksSizeStep, constants))
46         {
47             action(memory);
48         }
49     }
50 }

```

1.146 ./csharp/Platform.Data.Doublets.Tests/SplitMemoryUInt64LinksTests.cs

```

1  using System;
2  using Xunit;
3  using Platform.Memory;
4  using Platform.Data.Doublets.Memory.Split.Specific;
5  using TLink = System.UInt64;
6
7  namespace Platform.Data.Doublets.Tests
8  {
9      public unsafe static class SplitMemoryUInt64LinksTests
10     {
11         [Fact]
12         public static void CRUDTest()
13         {
14             Using(links => links.TestCRUDOperations());
15         }
16
17         [Fact]
18         public static void RawNumbersCRUDTest()
19         {
20             UsingWithExternalReferences(links => links.TestRawNumbersCRUDOperations());
21         }
22
23         [Fact]
24         public static void MultipleRandomCreationsAndDeletionsTest()
25         {
26             Using(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().TestMultipleRandomCreationsAndDeletions(100));
27         }
28
29         private static void Using(Action<ILinks<TLink>> action)
30         {
31             using (var dataMemory = new HeapResizableDirectMemory())
32             using (var indexMemory = new HeapResizableDirectMemory())
33             using (var memory = new UInt64SplitMemoryLinks(dataMemory, indexMemory))
34             {
35                 action(memory);
36             }
37         }
38     }
39 }

```



```

37     }
38
39     private static void UsingWithExternalReferences(Action<ILinks<TLink>> action)
40     {
41         var constants = new LinksConstants<TLink>(enableExternalReferencesSupport: true);
42         using (var dataMemory = new HeapResizableDirectMemory())
43         using (var indexMemory = new HeapResizableDirectMemory())
44         using (var memory = new UInt64SplitMemoryLinks(dataMemory, indexMemory,
45             ↪ UInt64SplitMemoryLinks.DefaultLinksSizeStep, constants))
46         {
47             action(memory);
48         }
49     }
50 }

```

1.147 ./csharp/Platform.Data.Doublets.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
7  namespace Platform.Data.Doublets.Tests
8  {
9      public class TempLinksTestScope : DisposableBase
10     {
11         public ILinks<ulong> MemoryAdapter { get; }
12         public SynchronizedLinks<ulong> Links { get; }
13         public Sequences.Sequences Sequences { get; }
14         public string TempFilename { get; }
15         public string TempTransactionLogFilename { get; }
16         private readonly bool _deleteFiles;
17
18         public TempLinksTestScope(bool deleteFiles = true, bool useSequences = false, bool
19             ↪ useLog = false) : this(new SequencesOptions<ulong>(), deleteFiles, useSequences,
20             ↪ useLog) { }
21
22         public TempLinksTestScope(SequencesOptions<ulong> sequencesOptions, bool deleteFiles =
23             ↪ true, bool useSequences = false, bool useLog = false)
24         {
25             _deleteFiles = deleteFiles;
26             TempFilename = Path.GetTempFileName();
27             TempTransactionLogFilename = Path.GetTempFileName();
28             var coreMemoryAdapter = new UInt64UnitedMemoryLinks(TempFilename);
29             MemoryAdapter = useLog ? (ILinks<ulong>)new
30                 ↪ UInt64LinksTransactionsLayer(coreMemoryAdapter, TempTransactionLogFilename) :
31                 ↪ coreMemoryAdapter;
32             Links = new SynchronizedLinks<ulong>(new UInt64Links(MemoryAdapter));
33             if (useSequences)
34             {
35                 Sequences = new Sequences.Sequences(Links, sequencesOptions);
36             }
37         }
38
39         protected override void Dispose(bool manual, bool wasDisposed)
40         {
41             if (!wasDisposed)
42             {
43                 Links.Unsync.DisposeIfPossible();
44                 if (_deleteFiles)
45                 {
46                     DeleteFiles();
47                 }
48             }
49         }
50
51         public void DeleteFiles()
52         {
53             File.Delete(TempFilename);
54             File.Delete(TempTransactionLogFilename);
55         }
56     }
57 }

```

1.148 ./csharp/Platform.Data.Doublets.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.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
109     var link2 = new Link<T>(links.GetLink(linkAddress2));
110
111     Assert.True(equalityComparer.Equals(link2.Source, linkAddress1));
112     Assert.True(equalityComparer.Equals(link2.Target, h108E));
113
114     // Create Link (Internal -> Internal)
115     var linkAddress3 = links.Create();
116
117     links.Update(linkAddress3, linkAddress1, linkAddress2);
118
119     var link3 = new Link<T>(links.GetLink(linkAddress3));
120
121     Assert.True(equalityComparer.Equals(link3.Source, linkAddress1));
122     Assert.True(equalityComparer.Equals(link3.Target, linkAddress2));
123
124     // Search for created link
125     var setter1 = new Setter<T>(constants.Null);
126     links.Each(h106E, h108E, setter1.SetAndReturnFalse);
127
128     Assert.True(equalityComparer.Equals(setter1.Result, linkAddress1));
129
130     // Search for nonexistent link
131     var setter2 = new Setter<T>(constants.Null);
132     links.Each(h106E, h107E, setter2.SetAndReturnFalse);
133
134     Assert.True(equalityComparer.Equals(setter2.Result, constants.Null));
135
136     // Update link to reference null (prepare for delete)
137     var updated = links.Update(linkAddress3, constants.Null, constants.Null);
138
139     Assert.True(equalityComparer.Equals(updated, linkAddress3));
140
141     link3 = new Link<T>(links.GetLink(linkAddress3));
142
143     Assert.True(equalityComparer.Equals(link3.Source, constants.Null));
144     Assert.True(equalityComparer.Equals(link3.Target, constants.Null));
145
146     // Delete link
147     links.Delete(linkAddress3);
148
149     Assert.True(equalityComparer.Equals(links.Count(), two));
150
151     var setter3 = new Setter<T>(constants.Null);
152     links.Each(constants.Any, constants.Any, setter3.SetAndReturnTrue);
153
154     Assert.True(equalityComparer.Equals(setter3.Result, linkAddress2));
155 }
156
157 public static void TestMultipleRandomCreationsAndDeletions<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));
                    ↪ //-V3086
176                 var resultLink = links.GetOrCreate(source, target);
177                 if (comparer.Compare(resultLink,
                    ↪ uInt64ToAddressConverter.Convert(linksCount)) > 0)
178                 {
179                     created++;
180                 }
181             }
182             else
183             {
184                 links.Create();
185                 created++;
186             }
187         }
188         Assert.True(created == addressToUInt64Converter.Convert(links.Count()));
189         for (var i = 0; i < N; i++)
190         {
191             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 }

```

1.149 ./csharp/Platform.Data.Doublets.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.Tests
24 {
25     public static class UInt64LinksTests
26     {
27         private static readonly LinksConstants<ulong> _constants =
28             ↪ Default<LinksConstants<ulong>>.Instance;
29
30         private const long Iterations = 10 * 1024;
31
32         #region Concept
33
34         [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>>()).TestMultipleRandomCreationsAndDeleti
40         ↳ ons(100);
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         l2 = links.Update(l2, l1);
60
61         links.Delete(l2);
62
63         Global.Trash = links.Count();
64
65         links.Unsync.DisposeIfPossible(); // Close links to access log
66
67         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(scop
68         ↳ e.TempTransactionLogFilename);
69     }
70 }
71 [Fact]
72 public static void BasicTransactionLogTest()
73 {
74     using (var scope = new TempLinksTestScope(useLog: true))
75     {
76         var links = scope.Links;
77         var l1 = links.Create();
78         var l2 = links.Create();
79
80         Global.Trash = links.Update(l2, l2, l1, l2);
81
82         links.Delete(l1);
83
84         links.Unsync.DisposeIfPossible(); // Close links to access log
85
86         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(scop
87         ↳ e.TempTransactionLogFilename);
88     }
89 }
90 [Fact]
91 public static void TransactionAutoRevertedTest()
92 {
93     // Auto Reverted (Because no commit at transaction)
94     using (var scope = new TempLinksTestScope(useLog: true))
95     {
96         var links = scope.Links;
97         var transactionsLayer = (UInt64LinksTransactionsLayer)scope.MemoryAdapter;
98         using (var transaction = transactionsLayer.BeginTransaction())
99         {
100             var l1 = links.Create();
101             var l2 = links.Create();
102
103             links.Update(l2, l2, l1, l2);
104         }
105
106         Assert.Equal(0UL, links.Count());
107
108         links.Unsync.DisposeIfPossible();

```

```

109         var transitions = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(s
110             ↪ cope.TempTransactionLogFilename);
111         Assert.Single(transitions);
112     }
113 }
114 [Fact]
115 public static void TransactionUserCodeErrorNoDataSavedTest()
116 {
117     // User Code Error (Autoreverted), no data saved
118     var itself = _constants.Itself;
119
120     TempLinksTestScope lastScope = null;
121     try
122     {
123         using (var scope = lastScope = new TempLinksTestScope(deleteFiles: false,
124             ↪ useLog: true))
125         {
126             var links = scope.Links;
127             var transactionsLayer = (UInt64LinksTransactionsLayer)((LinksDisposableDecor
128                 ↪ atorBase<ulong>)links.Unsync).Links;
129             using (var transaction = transactionsLayer.BeginTransaction())
130             {
131                 var l1 = links.CreateAndUpdate(itself, itself);
132                 var l2 = links.CreateAndUpdate(itself, itself);
133
134                 l2 = links.Update(l2, l2, l1, l2);
135
136                 links.CreateAndUpdate(l2, itself);
137                 links.CreateAndUpdate(l2, itself);
138
139                 //Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transi
140                     ↪ tion>(scope.TempTransactionLogFilename);
141
142                 l2 = links.Update(l2, l1);
143
144                 links.Delete(l2);
145
146                 ExceptionThrower();
147
148                 transaction.Commit();
149             }
150             Global.Trash = links.Count();
151         }
152     }
153     catch
154     {
155         Assert.False(lastScope == null);
156
157         var transitions = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(l
158             ↪ astScope.TempTransactionLogFilename);
159
160         Assert.True(transitions.Length == 1 && transitions[0].Before.IsNull() &&
161             ↪ transitions[0].After.IsNull());
162
163         lastScope.DeleteFiles();
164     }
165 }
166 [Fact]
167 public static void TransactionUserCodeErrorSomeDataSavedTest()
168 {
169     // User Code Error (Autoreverted), some data saved
170     var itself = _constants.Itself;
171
172     TempLinksTestScope lastScope = null;
173     try
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         Global.Trash = links.Count();
209     }
210 }
211 catch
212 {
213     Assert.False(lastScope == null);
214
215     Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(last
216         ↪ Scope.TempTransactionLogFilename);
217
218     lastScope.DeleteFiles();
219 }
220 }
221
222 [Fact]
223 public static void TransactionCommit()
224 {
225     var itself = _constants.Itself;
226
227     var tempDatabaseFilename = Path.GetTempFileName();
228     var tempTransactionLogFilename = Path.GetTempFileName();
229
230     // Commit
231     using (var memoryAdapter = new UInt64LinksTransactionsLayer(new
232         ↪ UInt64UnitedMemoryLinks(tempDatabaseFilename), tempTransactionLogFilename))
233     using (var links = new UInt64Links(memoryAdapter))
234     {
235         using (var transaction = memoryAdapter.BeginTransaction())
236         {
237             var l1 = links.CreateAndUpdate(itself, itself);
238             var l2 = links.CreateAndUpdate(itself, itself);
239
240             Global.Trash = links.Update(l2, l2, l1, l2);
241
242             links.Delete(l1);
243
244             transaction.Commit();
245         }
246
247         Global.Trash = links.Count();
248     }
249
250     Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran
251         ↪ sactionLogFilename);
252 }
253
254 [Fact]
255 public static void TransactionDamage()
256 {
257     var itself = _constants.Itself;
258
259     var tempDatabaseFilename = Path.GetTempFileName();
260     var tempTransactionLogFilename = Path.GetTempFileName();

```

```

257 // Commit
258 using (var memoryAdapter = new UInt64LinksTransactionsLayer(new
    ↳ UInt64UnitedMemoryLinks(tempDatabaseFilename), tempTransactionLogFilename))
259 using (var links = new UInt64Links(memoryAdapter))
260 {
261     using (var transaction = memoryAdapter.BeginTransaction())
262     {
263         var l1 = links.CreateAndUpdate(itself, itself);
264         var l2 = links.CreateAndUpdate(itself, itself);
265
266         Global.Trash = links.Update(l2, l2, l1, l2);
267
268         links.Delete(l1);
269
270         transaction.Commit();
271     }
272
273     Global.Trash = links.Count();
274 }
275
276 Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran_
    ↳ sactionLogFilename);
277
278 // Damage database
279
280 FileHelpers.WriteFirst(tempTransactionLogFilename, new
    ↳ UInt64LinksTransactionsLayer.Transition(new UniqueTimestampFactory(), 555));
281
282 // Try load damaged database
283 try
284 {
285     // TODO: Fix
286     using (var memoryAdapter = new UInt64LinksTransactionsLayer(new
        ↳ UInt64UnitedMemoryLinks(tempDatabaseFilename), tempTransactionLogFilename))
287     using (var links = new UInt64Links(memoryAdapter))
288     {
289         Global.Trash = links.Count();
290     }
291 }
292 catch (NotSupportedException ex)
293 {
294     Assert.True(ex.Message == "Database is damaged, autorecovery is not supported
        ↳ yet.");
295 }
296
297 Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran_
    ↳ sactionLogFilename);
298
299 File.Delete(tempDatabaseFilename);
300 File.Delete(tempTransactionLogFilename);
301 }
302
303 [Fact]
304 public static void Bug1Test()
305 {
306     var tempDatabaseFilename = Path.GetTempFileName();
307     var tempTransactionLogFilename = Path.GetTempFileName();
308
309     var itself = _constants.Itself;
310
311     // User Code Error (Autoreverted), some data saved
312     try
313     {
314         ulong l1;
315         ulong l2;
316
317         using (var memory = new UInt64UnitedMemoryLinks(tempDatabaseFilename))
318         using (var memoryAdapter = new UInt64LinksTransactionsLayer(memory,
            ↳ tempTransactionLogFilename))
319         using (var links = new UInt64Links(memoryAdapter))
320         {
321             l1 = links.CreateAndUpdate(itself, itself);
322             l2 = links.CreateAndUpdate(itself, itself);
323
324             l2 = links.Update(l2, l2, l1, l2);
325
326             links.CreateAndUpdate(l2, itself);
327             links.CreateAndUpdate(l2, itself);
328         }

```



```

329     Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(temp
330     ↪ TransactionLogFilename);
331
332     using (var memory = new UInt64UnitedMemoryLinks(tempDatabaseFilename))
333     using (var memoryAdapter = new UInt64LinksTransactionsLayer(memory,
334     ↪ tempTransactionLogFilename))
335     using (var links = new UInt64Links(memoryAdapter))
336     {
337         using (var transaction = memoryAdapter.BeginTransaction())
338         {
339             l2 = links.Update(l2, l1);
340
341             links.Delete(l2);
342
343             ExceptionThrower();
344
345             transaction.Commit();
346         }
347         Global.Trash = links.Count();
348     }
349 }
350 catch
351 {
352     Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(temp
353     ↪ TransactionLogFilename);
354 }
355
356 File.Delete(tempDatabaseFilename);
357 File.Delete(tempTransactionLogFilename);
358 }
359
360 private static void ExceptionThrower() => throw new InvalidOperationException();
361
362 [Fact]
363 public static void PathsTest()
364 {
365     var source = _constants.SourcePart;
366     var target = _constants.TargetPart;
367
368     using (var scope = new TempLinksTestScope())
369     {
370         var links = scope.Links;
371         var l1 = links.CreatePoint();
372         var l2 = links.CreatePoint();
373
374         var r1 = links.GetByKeys(l1, source, target, source);
375         var r2 = links.CheckPathExistence(l2, l2, l2, l2);
376     }
377 }
378
379 [Fact]
380 public static void RecursiveStringFormattingTest()
381 {
382     using (var scope = new TempLinksTestScope(useSequences: true))
383     {
384         var links = scope.Links;
385         var sequences = scope.Sequences; // TODO: Auto use sequences on Sequences getter.
386
387         var a = links.CreatePoint();
388         var b = links.CreatePoint();
389         var c = links.CreatePoint();
390
391         var ab = links.GetOrCreate(a, b);
392         var cb = links.GetOrCreate(c, b);
393         var ac = links.GetOrCreate(a, c);
394
395         a = links.Update(a, c, b);
396         b = links.Update(b, a, c);
397         c = links.Update(c, a, b);
398
399         Debug.WriteLine(links.FormatStructure(ab, link => link.IsFullPoint(), true));
400         Debug.WriteLine(links.FormatStructure(cb, link => link.IsFullPoint(), true));
401         Debug.WriteLine(links.FormatStructure(ac, link => link.IsFullPoint(), true));
402
403         Assert.True(links.FormatStructure(cb, link => link.IsFullPoint(), true) ==
404         ↪ "(5:(4:5 (6:5 4)) 6)");

```

```

403     Assert.True(links.FormatStructure(ac, link => link.IsFullPoint(), true) ==
404         ↳ "(6:(5:(4:5 6) 6) 4)");
405     Assert.True(links.FormatStructure(ab, link => link.IsFullPoint(), true) ==
406         ↳ "(4:(5:4 (6:5 4)) 6)");
407
408     // TODO: Think how to build balanced syntax tree while formatting structure (eg.
409     ↳ "(4:(5:4 6) (6:5 4))" instead of "(4:(5:4 (6:5 4)) 6)"
410
411     Assert.True(sequences.SafeFormatSequence(cb, DefaultFormatter, false) ==
412         ↳ "{5}{5}{4}{6}");
413     Assert.True(sequences.SafeFormatSequence(ac, DefaultFormatter, false) ==
414         ↳ "{5}{6}{6}{4}");
415     Assert.True(sequences.SafeFormatSequence(ab, DefaultFormatter, false) ==
416         ↳ "{4}{5}{4}{6}");
417 }
418
419 private static void DefaultFormatter(StringBuilder sb, ulong link)
420 {
421     sb.Append(link.ToString());
422 }
423
424 #endregion
425
426 #region Performance
427
428 /*
429 public static void RunAllPerformanceTests()
430 {
431     try
432     {
433         links.TestLinksInSteps();
434     }
435     catch (Exception ex)
436     {
437         ex.WriteToConsole();
438     }
439
440     return;
441
442     try
443     {
444         //ThreadPool.SetMaxThreads(2, 2);
445
446         // Запускаем все тесты дважды, чтобы первоначальная инициализация не повлияла на
447         ↳ результат
448         // Также это дополнительно помогает в отладке
449         // Увеличивает вероятность попадания информации в кэши
450         for (var i = 0; i < 10; i++)
451         {
452             //0 - 10 ГБ
453             //Каждые 100 МБ срез цифр
454
455             //links.TestGetSourceFunction();
456             //links.TestGetSourceFunctionInParallel();
457             //links.TestGetTargetFunction();
458             //links.TestGetTargetFunctionInParallel();
459             links.Create64BillionLinks();
460
461             links.TestRandomSearchFixed();
462             //links.Create64BillionLinksInParallel();
463             links.TestEachFunction();
464             //links.TestForeach();
465             //links.TestParallelForeach();
466         }
467
468         links.TestDeletionOfAllLinks();
469     }
470     catch (Exception ex)
471     {
472         ex.WriteToConsole();
473     }
474 }*/
475
476 /*
477 public static void TestLinksInSteps()
478 {
479     const long gibibyte = 1024 * 1024 * 1024;

```

```

475         const long mebibyte = 1024 * 1024;
476
477         var totalLinksToCreate = gibibyte /
↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
478         var linksStep = 102 * mebibyte /
↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
479
480         var creationMeasurements = new List<TimeSpan>();
481         var searchMeasurements = new List<TimeSpan>();
482         var deletionMeasurements = new List<TimeSpan>();
483
484         GetBaseRandomLoopOverhead(linksStep);
485         GetBaseRandomLoopOverhead(linksStep);
486
487         var stepLoopOverhead = GetBaseRandomLoopOverhead(linksStep);
488
489         ConsoleHelpers.Debug("Step loop overhead: {0}.", stepLoopOverhead);
490
491         var loops = totalLinksToCreate / linksStep;
492
493         for (int i = 0; i < loops; i++)
494         {
495             creationMeasurements.Add(Measure(() => links.RunRandomCreations(linksStep)));
496             searchMeasurements.Add(Measure(() => links.RunRandomSearches(linksStep)));
497
498             Console.WriteLine("\rC + S {0}/{1}", i + 1, loops);
499         }
500
501         ConsoleHelpers.Debug();
502
503         for (int i = 0; i < loops; i++)
504         {
505             deletionMeasurements.Add(Measure(() => links.RunRandomDeletions(linksStep)));
506
507             Console.WriteLine("\rD {0}/{1}", i + 1, loops);
508         }
509
510         ConsoleHelpers.Debug();
511
512         ConsoleHelpers.Debug("C S D");
513
514         for (int i = 0; i < loops; i++)
515         {
516             ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i],
↪ searchMeasurements[i], deletionMeasurements[i]);
517         }
518
519         ConsoleHelpers.Debug("C S D (no overhead)");
520
521         for (int i = 0; i < loops; i++)
522         {
523             ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i] - stepLoopOverhead,
↪ searchMeasurements[i] - stepLoopOverhead, deletionMeasurements[i] - stepLoopOverhead);
524         }
525
526         ConsoleHelpers.Debug("All tests done. Total links left in database: {0}.",
↪ links.Total);
527     }
528
529     private static void CreatePoints(this Platform.Links.Data.Core.Doublets.Links links, long
↪ 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         });
549     }

```

```

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;
577
578         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
579
580         // Удаляем связь, из которой производилось считывание
581         links.Delete(firstLink);
582
583         ConsoleHelpers.Debug(
584             "{0} Iterations of GetSource function done in {1} ({2} Iterations per
585             ↪ second), counter result: {3}",
586             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
587     }
588 }
589
590 [Fact(Skip = "performance test")]
591 public static void GetSourceInParallel()
592 {
593     using (var scope = new TempLinksTestScope())
594     {
595         var links = scope.Links;
596         ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations in
597             ↪ parallel.", Iterations);
598
599         long counter = 0;
600
601         //var firstLink = links.First();
602         var firstLink = links.Create();
603
604         var sw = Stopwatch.StartNew();
605
606         // Тестируем саму функцию
607         Parallel.For(0, Iterations, x =>
608         {
609             Interlocked.Add(ref counter, (long)links.GetSource(firstLink));
610             //Interlocked.Increment(ref counter);
611         });
612
613         var elapsedTime = sw.Elapsed;
614
615         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
616
617         links.Delete(firstLink);
618
619         ConsoleHelpers.Debug(
620             "{0} Iterations of GetSource function done in {1} ({2} Iterations per
621             ↪ second), counter result: {3}",
622             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
623     }
624 }
625
626 [Fact(Skip = "performance test")]

```

```

623 public static void TestGetTarget()
624 {
625     using (var scope = new TempLinksTestScope())
626     {
627         var links = scope.Links;
628         ConsoleHelpers.Debug("Testing GetTarget function with {0} Iterations.",
629                               ↪ Iterations);
630
631         ulong counter = 0;
632
633         //var firstLink = links.First();
634         var firstLink = links.Create();
635
636         var sw = Stopwatch.StartNew();
637
638         for (ulong i = 0; i < Iterations; i++)
639         {
640             counter += links.GetTarget(firstLink);
641         }
642
643         var elapsedTime = sw.Elapsed;
644
645         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
646
647         links.Delete(firstLink);
648
649         ConsoleHelpers.Debug(
650             "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
651             ↪ second), counter result: {3}",
652             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
653     }
654 }
655
656 [Fact(Skip = "performance test")]
657 public static void TestGetTargetInParallel()
658 {
659     using (var scope = new TempLinksTestScope())
660     {
661         var links = scope.Links;
662         ConsoleHelpers.Debug("Testing GetTarget function with {0} Iterations in
663             ↪ parallel.", Iterations);
664
665         long counter = 0;
666
667         //var firstLink = links.First();
668         var firstLink = links.Create();
669
670         var sw = Stopwatch.StartNew();
671
672         Parallel.For(0, Iterations, x =>
673         {
674             Interlocked.Add(ref counter, (long)links.GetTarget(firstLink));
675             //Interlocked.Increment(ref counter);
676         });
677
678         var elapsedTime = sw.Elapsed;
679
680         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
681
682         links.Delete(firstLink);
683
684         ConsoleHelpers.Debug(
685             "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
686             ↪ second), counter result: {3}",
687             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
688     }
689 }
690
691 // TODO: Заполнить базу данных перед тестом
692 /*
693 [Fact]
694 public void TestRandomSearchFixed()
695 {
696     var tempFilename = Path.GetTempFileName();
697
698     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
699 ↪ DefaultLinksSizeStep))
700     {
701         long iterations = 64 * 1024 * 1024 /
702 ↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;

```

```

697         ulong counter = 0;
698         var maxLink = links.Total;
699
700         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.", iterations);
701
702         var sw = Stopwatch.StartNew();
703
704         for (var i = iterations; i > 0; i--)
705         {
706             var source =
707 ↪ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
708             var target =
709 ↪ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
710
711             counter += links.Search(source, target);
712         }
713
714         var elapsedTime = sw.Elapsed;
715
716         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
717
718         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
719 ↪ Iterations per second), c: {3}", iterations, elapsedTime, (long)iterationsPerSecond,
720 ↪ counter);
721     }
722
723     File.Delete(tempFilename);
724 }*/
725
726 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
727 public static void TestRandomSearchAll()
728 {
729     using (var scope = new TempLinksTestScope())
730     {
731         var links = scope.Links;
732         ulong counter = 0;
733
734         var maxLink = links.Count();
735
736         var iterations = links.Count();
737
738         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.",
739 ↪ links.Count());
740
741         var sw = Stopwatch.StartNew();
742
743         for (var i = iterations; i > 0; i--)
744         {
745             var linksAddressRange = new
746 ↪ Range<ulong>(_constants.InternalReferencesRange.Minimum, maxLink);
747
748             var source = RandomHelpers.Default.NextUInt64(linksAddressRange);
749             var target = RandomHelpers.Default.NextUInt64(linksAddressRange);
750
751             counter += links.SearchOrDefault(source, target);
752         }
753
754         var elapsedTime = sw.Elapsed;
755
756         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
757
758         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
759 ↪ Iterations per second), c: {3}",
760 ↪ iterations, elapsedTime, (long)iterationsPerSecond, counter);
761     }
762 }
763
764 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
765 public static void TestEach()
766 {
767     using (var scope = new TempLinksTestScope())
768     {
769         var links = scope.Links;
770
771         var counter = new Counter<IList<ulong>, ulong>(links.Constants.Continue);
772
773         ConsoleHelpers.Debug("Testing Each function.");
774
775         var sw = Stopwatch.StartNew();

```

```

770         links.Each(counter.IncrementAndReturnTrue);
771     }
772     var elapsedTime = sw.Elapsed;
773     var linksPerSecond = counter.Count / elapsedTime.TotalSeconds;
774     ConsoleHelpers.Debug("{0} Iterations of Each's handler function done in {1} ({2}
775     ↪ links per second)",
776     counter, elapsedTime, (long)linksPerSecond);
777 }
778 }
779 }
780 }
781 }
782 /*
783 [Fact]
784 public static void TestForeach()
785 {
786     var tempFilename = Path.GetTempFileName();
787     using (var links = new Platform.Links.Data.Core.Doublents.Links(tempFilename,
788     ↪ DefaultLinksSizeStep))
789     {
790         ulong counter = 0;
791         ConsoleHelpers.Debug("Testing foreach through links.");
792         var sw = Stopwatch.StartNew();
793         //foreach (var link in links)
794         //{
795             counter++;
796         //}
797         var elapsedTime = sw.Elapsed;
798         var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
799         ConsoleHelpers.Debug("{0} Iterations of Foreach's handler block done in {1} ({2}
800     ↪ links per second)", counter, elapsedTime, (long)linksPerSecond);
801     }
802     File.Delete(tempFilename);
803 }
804 */
805 /*
806 [Fact]
807 public static void TestParallelForeach()
808 {
809     var tempFilename = Path.GetTempFileName();
810     using (var links = new Platform.Links.Data.Core.Doublents.Links(tempFilename,
811     ↪ DefaultLinksSizeStep))
812     {
813         long counter = 0;
814         ConsoleHelpers.Debug("Testing parallel foreach through links.");
815         var sw = Stopwatch.StartNew();
816         //Parallel.ForEach((IEnumerable<ulong>)links, x =>
817         //{
818             Interlocked.Increment(ref counter);
819         //});
820         var elapsedTime = sw.Elapsed;
821         var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
822         ConsoleHelpers.Debug("{0} Iterations of Parallel Foreach's handler block done in
823     ↪ {1} ({2} links per second)", counter, elapsedTime, (long)linksPerSecond);
824     }
825     File.Delete(tempFilename);
826 }
827 */
828 [Fact(Skip = "performance test")]
829 public static void Create64BillionLinks()

```

```

845 {
846     using (var scope = new TempLinksTestScope())
847     {
848         var links = scope.Links;
849         var linksBeforeTest = links.Count();
850
851         long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
852
853         ConsoleHelpers.Debug("Creating {0} links.", linksToCreate);
854
855         var elapsedTime = Performance.Measure(() =>
856         {
857             for (long i = 0; i < linksToCreate; i++)
858             {
859                 links.Create();
860             }
861         });
862
863         var linksCreated = links.Count() - linksBeforeTest;
864         var linksPerSecond = linksCreated / elapsedTime.TotalSeconds;
865
866         ConsoleHelpers.Debug("Current links count: {0}.", links.Count());
867
868         ConsoleHelpers.Debug("{0} links created in {1} ({2} links per second)",
869             ↪ linksCreated, elapsedTime,
870             (long)linksPerSecond);
871     }
872 }
873 [Fact(Skip = "performance test")]
874 public static void Create64BillionLinksInParallel()
875 {
876     using (var scope = new TempLinksTestScope())
877     {
878         var links = scope.Links;
879         var linksBeforeTest = links.Count();
880
881         var sw = Stopwatch.StartNew();
882
883         long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
884
885         ConsoleHelpers.Debug("Creating {0} links in parallel.", linksToCreate);
886
887         Parallel.For(0, linksToCreate, x => links.Create());
888
889         var elapsedTime = sw.Elapsed;
890
891         var linksCreated = links.Count() - linksBeforeTest;
892         var linksPerSecond = linksCreated / elapsedTime.TotalSeconds;
893
894         ConsoleHelpers.Debug("{0} links created in {1} ({2} links per second)",
895             ↪ linksCreated, elapsedTime,
896             (long)linksPerSecond);
897     }
898 }
899 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
900 public static void TestDeletionOfAllLinks()
901 {
902     using (var scope = new TempLinksTestScope())
903     {
904         var links = scope.Links;
905         var linksBeforeTest = links.Count();
906
907         ConsoleHelpers.Debug("Deleting all links");
908
909         var elapsedTime = Performance.Measure(links.DeleteAll);
910
911         var linksDeleted = linksBeforeTest - links.Count();
912         var linksPerSecond = linksDeleted / elapsedTime.TotalSeconds;
913
914         ConsoleHelpers.Debug("{0} links deleted in {1} ({2} links per second)",
915             ↪ linksDeleted, elapsedTime,
916             (long)linksPerSecond);
917     }
918 }
919 #endregion
920 }
921 }

```


1.150 ./csharp/Platform.Data.Doublets.Tests/UnaryNumberConvertersTests.cs

```

1  using Xunit;
2  using Platform.Random;
3  using Platform.Data.Doublets.Numbers.Unary;
4
5  namespace Platform.Data.Doublets.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 }

```

1.151 ./csharp/Platform.Data.Doublets.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.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);

```

```

31         var unaryNumberToAddressConverter = new
           ↳ UnaryNumberToAddressOrOperationConverter<ulong>(links,
           ↳ powerOf2ToUnaryNumberConverter);
32     TestCharAndUnicodeSymbolConverters(links, meaningRoot,
           ↳ addressToUnaryNumberConverter, unaryNumberToAddressConverter);
33     }
34 }
35
36 [Fact]
37 public static void CharAndRawNumberUnicodeSymbolConvertersTest()
38 {
39     using (var scope = new Scope<Types<HeapResizableDirectMemory,
           ↳ UnitedMemoryLinks<ulong>>>())
40     {
41         var links = scope.Use<ILinks<ulong>>>();
42         var meaningRoot = links.CreatePoint();
43         var addressToRawNumberConverter = new AddressToRawNumberConverter<ulong>();
44         var rawNumberToAddressConverter = new RawNumberToAddressConverter<ulong>();
45         TestCharAndUnicodeSymbolConverters(links, meaningRoot,
           ↳ addressToRawNumberConverter, rawNumberToAddressConverter);
46     }
47 }
48
49 private static void TestCharAndUnicodeSymbolConverters(ILinks<ulong> links, ulong
           ↳ meaningRoot, IConverter<ulong> addressToNumberConverter, IConverter<ulong>
           ↳ numberToAddressConverter)
50 {
51     var unicodeSymbolMarker = links.CreateAndUpdate(meaningRoot, links.Constants.Itself);
52     var charToUnicodeSymbolConverter = new CharToUnicodeSymbolConverter<ulong>(links,
           ↳ addressToNumberConverter, unicodeSymbolMarker);
53     var originalCharacter = 'H';
54     var characterLink = charToUnicodeSymbolConverter.Convert(originalCharacter);
55     var unicodeSymbolCriterionMatcher = new TargetMatcher<ulong>(links,
           ↳ unicodeSymbolMarker);
56     var unicodeSymbolToCharConverter = new UnicodeSymbolToCharConverter<ulong>(links,
           ↳ numberToAddressConverter, unicodeSymbolCriterionMatcher);
57     var resultingCharacter = unicodeSymbolToCharConverter.Convert(characterLink);
58     Assert.Equal(originalCharacter, resultingCharacter);
59 }
60
61 [Fact]
62 public static void StringAndUnicodeSequenceConvertersTest()
63 {
64     using (var scope = new TempLinksTestScope())
65     {
66         var links = scope.Links;
67
68         var itself = links.Constants.Itself;
69
70         var meaningRoot = links.CreatePoint();
71         var unaryOne = links.CreateAndUpdate(meaningRoot, itself);
72         var unicodeSymbolMarker = links.CreateAndUpdate(meaningRoot, itself);
73         var unicodeSequenceMarker = links.CreateAndUpdate(meaningRoot, itself);
74         var frequencyMarker = links.CreateAndUpdate(meaningRoot, itself);
75         var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot, itself);
76
77         var powerOf2ToUnaryNumberConverter = new
           ↳ PowerOf2ToUnaryNumberConverter<ulong>(links, unaryOne);
78         var addressToUnaryNumberConverter = new
           ↳ AddressToUnaryNumberConverter<ulong>(links, powerOf2ToUnaryNumberConverter);
79         var charToUnicodeSymbolConverter = new
           ↳ CharToUnicodeSymbolConverter<ulong>(links, addressToUnaryNumberConverter,
           ↳ unicodeSymbolMarker);
80
81         var unaryNumberToAddressConverter = new
           ↳ UnaryNumberToAddressOrOperationConverter<ulong>(links,
           ↳ powerOf2ToUnaryNumberConverter);
82         var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links, unaryOne);
83         var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
           ↳ frequencyMarker, unaryOne, unaryNumberIncrementer);
84         var frequencyPropertyOperator = new PropertyOperator<ulong>(links,
           ↳ frequencyPropertyMarker, frequencyMarker);
85         var index = new FrequencyIncrementingSequenceIndex<ulong>(links,
           ↳ frequencyPropertyOperator, frequencyIncrementer);
86         var linkToItsFrequencyNumberConverter = new
           ↳ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
           ↳ unaryNumberToAddressConverter);

```

```

87     var sequenceToItsLocalElementLevelsConverter = new
      ↳ SequenceToItsLocalElementLevelsConverter<ulong>(links,
      ↳ linkToItsFrequencyNumberConverter);
88     var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
      ↳ sequenceToItsLocalElementLevelsConverter);
89
90     var stringToUnicodeSequenceConverter = new
      ↳ StringToUnicodeSequenceConverter<ulong>(links, charToUnicodeSymbolConverter,
      ↳ index, optimalVariantConverter, unicodeSequenceMarker);
91
92     var originalString = "Hello";
93
94     var unicodeSequenceLink =
      ↳ stringToUnicodeSequenceConverter.Convert(originalString);
95
96     var unicodeSymbolCriterionMatcher = new TargetMatcher<ulong>(links,
      ↳ unicodeSymbolMarker);
97     var unicodeSymbolToCharConverter = new
      ↳ UnicodeSymbolToCharConverter<ulong>(links, unaryNumberToAddressConverter,
      ↳ unicodeSymbolCriterionMatcher);
98
99     var unicodeSequenceCriterionMatcher = new TargetMatcher<ulong>(links,
      ↳ unicodeSequenceMarker);
100
101     var sequenceWalker = new LeveledSequenceWalker<ulong>(links,
      ↳ unicodeSymbolCriterionMatcher.IsMatched);
102
103     var unicodeSequenceToStringConverter = new
      ↳ UnicodeSequenceToStringConverter<ulong>(links,
      ↳ unicodeSequenceCriterionMatcher, sequenceWalker,
      ↳ unicodeSymbolToCharConverter);
104
105     var resultingString =
      ↳ unicodeSequenceToStringConverter.Convert(unicodeSequenceLink);
106
107     Assert.Equal(originalString, resultingString);
108 }
109 }
110 }
111 }

```

1.152 ./csharp/Platform.Data.Doublets.Tests/UnitedMemoryUInt32LinksTests.cs

```

1  using System;
2  using Xunit;
3  using Platform.Reflection;
4  using Platform.Memory;
5  using Platform.Scopes;
6  using Platform.Data.Doublets.Memory.United.Specific;
7  using TLink = System.UInt32;
8
9  namespace Platform.Data.Doublets.Tests
10 {
11     public unsafe static class UnitedMemoryUInt32LinksTests
12     {
13         [Fact]
14         public static void CRUDTest()
15         {
16             Using(links => links.TestCRUDOperations());
17         }
18
19         [Fact]
20         public static void RawNumbersCRUDTest()
21         {
22             Using(links => links.TestRawNumbersCRUDOperations());
23         }
24
25         [Fact]
26         public static void MultipleRandomCreationsAndDeletionsTest()
27         {
28             Using(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().TestMultipleRandomCreationsAndDeletions(100));
29         }
30
31         private static void Using(Action<ILinks<TLink>> action)
32         {
33             using (var scope = new Scope<Types<HeapResizableDirectMemory,
34                 ↳ UInt32UnitedMemoryLinks>>())
35             {
36                 action(scope.Use<ILinks<TLink>>());
37             }
38         }
39     }
40 }

```

```

36     }
37 }
38 }
39 }

```

1.153 ./csharp/Platform.Data.Doublets.Tests/UnitedMemoryUInt64LinksTests.cs

```

1  using System;
2  using Xunit;
3  using Platform.Reflection;
4  using Platform.Memory;
5  using Platform.Scopes;
6  using Platform.Data.Doublets.Memory.United.Specific;
7  using TLink = System.UInt64;
8
9  namespace Platform.Data.Doublets.Tests
10 {
11     public unsafe static class UnitedMemoryUInt64LinksTests
12     {
13         [Fact]
14         public static void CRUDTest()
15         {
16             Using(links => links.TestCRUDOperations());
17         }
18
19         [Fact]
20         public static void RawNumbersCRUDTest()
21         {
22             Using(links => links.TestRawNumbersCRUDOperations());
23         }
24
25         [Fact]
26         public static void MultipleRandomCreationsAndDeletionsTest()
27         {
28             Using(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().TestMultipleRandomCreationsAndDeletions(100));
29         }
30
31         private static void Using(Action<ILinks<TLink>> action)
32         {
33             using (var scope = new Scope<Types<HeapResizableDirectMemory,
34                 ↳ UInt64UnitedMemoryLinks>>())
35             {
36                 action(scope.Use<ILinks<TLink>>());
37             }
38         }
39     }

```

Index

[./csharp/Platform.Data.Doublets.Tests/GenericLinksTests.cs](#), 193
[./csharp/Platform.Data.Doublets.Tests/ILinksExtensionsTests.cs](#), 194
[./csharp/Platform.Data.Doublets.Tests/LinksConstantsTests.cs](#), 194
[./csharp/Platform.Data.Doublets.Tests/OptimalVariantSequenceTests.cs](#), 194
[./csharp/Platform.Data.Doublets.Tests/ReadSequenceTests.cs](#), 197
[./csharp/Platform.Data.Doublets.Tests/ResizableDirectMemoryLinksTests.cs](#), 198
[./csharp/Platform.Data.Doublets.Tests/ScopeTests.cs](#), 199
[./csharp/Platform.Data.Doublets.Tests/SequencesTests.cs](#), 200
[./csharp/Platform.Data.Doublets.Tests/SplitMemoryGenericLinksTests.cs](#), 215
[./csharp/Platform.Data.Doublets.Tests/SplitMemoryUInt32LinksTests.cs](#), 215
[./csharp/Platform.Data.Doublets.Tests/SplitMemoryUInt64LinksTests.cs](#), 216
[./csharp/Platform.Data.Doublets.Tests/TempLinksTestScope.cs](#), 217
[./csharp/Platform.Data.Doublets.Tests/TestExtensions.cs](#), 217
[./csharp/Platform.Data.Doublets.Tests/UInt64LinksTests.cs](#), 220
[./csharp/Platform.Data.Doublets.Tests/UnaryNumberConvertersTests.cs](#), 233
[./csharp/Platform.Data.Doublets.Tests/UnicodeConvertersTests.cs](#), 233
[./csharp/Platform.Data.Doublets.Tests/UnitedMemoryUInt32LinksTests.cs](#), 235
[./csharp/Platform.Data.Doublets.Tests/UnitedMemoryUInt64LinksTests.cs](#), 236
[./csharp/Platform.Data.Doublets/CriterionMatchers/TargetMatcher.cs](#), 1
[./csharp/Platform.Data.Doublets/Decorators/LinksCascadeUniquenessAndUsagesResolver.cs](#), 1
[./csharp/Platform.Data.Doublets/Decorators/LinksCascadeUsagesResolver.cs](#), 1
[./csharp/Platform.Data.Doublets/Decorators/LinksDecoratorBase.cs](#), 1
[./csharp/Platform.Data.Doublets/Decorators/LinksDisposableDecoratorBase.cs](#), 2
[./csharp/Platform.Data.Doublets/Decorators/LinksInnerReferenceExistenceValidator.cs](#), 3
[./csharp/Platform.Data.Doublets/Decorators/LinksItselfConstantToSelfReferenceResolver.cs](#), 3
[./csharp/Platform.Data.Doublets/Decorators/LinksNonExistentDependenciesCreator.cs](#), 4
[./csharp/Platform.Data.Doublets/Decorators/LinksNullConstantToSelfReferenceResolver.cs](#), 4
[./csharp/Platform.Data.Doublets/Decorators/LinksUniquenessResolver.cs](#), 5
[./csharp/Platform.Data.Doublets/Decorators/LinksUniquenessValidator.cs](#), 5
[./csharp/Platform.Data.Doublets/Decorators/LinksUsagesValidator.cs](#), 5
[./csharp/Platform.Data.Doublets/Decorators/NonNullContentsLinkDeletionResolver.cs](#), 6
[./csharp/Platform.Data.Doublets/Decorators/UInt64Links.cs](#), 6
[./csharp/Platform.Data.Doublets/Decorators/UniLinks.cs](#), 7
[./csharp/Platform.Data.Doublets/Doublet.cs](#), 12
[./csharp/Platform.Data.Doublets/DoubletComparer.cs](#), 13
[./csharp/Platform.Data.Doublets/ILinks.cs](#), 13
[./csharp/Platform.Data.Doublets/ILinksExtensions.cs](#), 13
[./csharp/Platform.Data.Doublets/ISynchronizedLinks.cs](#), 25
[./csharp/Platform.Data.Doublets/Incrementers/FrequencyIncrementer.cs](#), 25
[./csharp/Platform.Data.Doublets/Incrementers/UnaryNumberIncrementer.cs](#), 26
[./csharp/Platform.Data.Doublets/Link.cs](#), 26
[./csharp/Platform.Data.Doublets/LinkExtensions.cs](#), 29
[./csharp/Platform.Data.Doublets/LinksOperatorBase.cs](#), 29
[./csharp/Platform.Data.Doublets/Memory/ILinksListMethods.cs](#), 30
[./csharp/Platform.Data.Doublets/Memory/ILinksTreeMethods.cs](#), 30
[./csharp/Platform.Data.Doublets/Memory/IndexTreeType.cs](#), 30
[./csharp/Platform.Data.Doublets/Memory/LinksHeader.cs](#), 30
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksSizeBalancedTreeMethodsBase.cs](#), 31
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksSourcesSizeBalancedTreeMethods.cs](#), 34
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksTargetsSizeBalancedTreeMethods.cs](#), 35
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksSizeBalancedTreeMethodsBase.cs](#), 36
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksSourcesSizeBalancedTreeMethods.cs](#), 39
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksTargetsSizeBalancedTreeMethods.cs](#), 40
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/SplitMemoryLinks.cs](#), 40
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/SplitMemoryLinksBase.cs](#), 42
[./csharp/Platform.Data.Doublets/Memory/Split/Generic/UnusedLinksListMethods.cs](#), 51
[./csharp/Platform.Data.Doublets/Memory/Split/RawLinkDataPart.cs](#), 52
[./csharp/Platform.Data.Doublets/Memory/Split/RawLinkIndexPart.cs](#), 53
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksSizeBalancedTreeMethodsBase.cs](#), 53
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksSourcesSizeBalancedTreeMethods.cs](#), 55
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksTargetsSizeBalancedTreeMethods.cs](#), 56
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSizeBalancedTreeMethodsBase.cs](#), 57
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSourcesSizeBalancedTreeMethods.cs](#), 58
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksTargetsSizeBalancedTreeMethods.cs](#), 59
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32SplitMemoryLinks.cs](#), 60
[./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32UnusedLinksListMethods.cs](#), 61

./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksSizeBalancedTreeMethodsBase.cs, 62
./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksSourcesSizeBalancedTreeMethods.cs, 63
./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksTargetsSizeBalancedTreeMethods.cs, 64
./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSizeBalancedTreeMethodsBase.cs, 65
./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSourcesSizeBalancedTreeMethods.cs, 66
./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksTargetsSizeBalancedTreeMethods.cs, 67
./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64SplitMemoryLinks.cs, 68
./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64UnusedLinksListMethods.cs, 69
./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksAvlBalancedTreeMethodsBase.cs, 70
./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksSizeBalancedTreeMethodsBase.cs, 74
./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksSourcesAvlBalancedTreeMethods.cs, 77
./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksSourcesSizeBalancedTreeMethods.cs, 78
./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksTargetsAvlBalancedTreeMethods.cs, 79
./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksTargetsSizeBalancedTreeMethods.cs, 80
./csharp/Platform.Data.Doublets/Memory/United/Generic/UnitedMemoryLinks.cs, 81
./csharp/Platform.Data.Doublets/Memory/United/Generic/UnitedMemoryLinksBase.cs, 83
./csharp/Platform.Data.Doublets/Memory/United/Generic/UnusedLinksListMethods.cs, 90
./csharp/Platform.Data.Doublets/Memory/United/RawLink.cs, 91
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksSizeBalancedTreeMethodsBase.cs, 91
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksSourcesSizeBalancedTreeMethods.cs, 93
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksTargetsSizeBalancedTreeMethods.cs, 93
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32UnitedMemoryLinks.cs, 94
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32UnusedLinksListMethods.cs, 96
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksAvlBalancedTreeMethodsBase.cs, 96
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSizeBalancedTreeMethodsBase.cs, 98
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSourcesAvlBalancedTreeMethods.cs, 99
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSourcesSizeBalancedTreeMethods.cs, 100
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksTargetsAvlBalancedTreeMethods.cs, 101
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksTargetsSizeBalancedTreeMethods.cs, 103
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64UnitedMemoryLinks.cs, 103
./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64UnusedLinksListMethods.cs, 105
./csharp/Platform.Data.Doublets/Numbers/Unary/AddressToUnaryNumberConverter.cs, 106
./csharp/Platform.Data.Doublets/Numbers/Unary/LinkToToltsFrequencyNumberConveter.cs, 106
./csharp/Platform.Data.Doublets/Numbers/Unary/PowerOf2ToUnaryNumberConverter.cs, 107
./csharp/Platform.Data.Doublets/Numbers/Unary/UnaryNumberToAddressAddOperationConverter.cs, 107
./csharp/Platform.Data.Doublets/Numbers/Unary/UnaryNumberToAddressOrOperationConverter.cs, 108
./csharp/Platform.Data.Doublets/PropertyOperators/PropertiesOperator.cs, 109
./csharp/Platform.Data.Doublets/PropertyOperators/PropertyOperator.cs, 110
./csharp/Platform.Data.Doublets/Sequences/Converters/BalancedVariantConverter.cs, 111
./csharp/Platform.Data.Doublets/Sequences/Converters/CompressingConverter.cs, 112
./csharp/Platform.Data.Doublets/Sequences/Converters/LinksListToSequenceConverterBase.cs, 115
./csharp/Platform.Data.Doublets/Sequences/Converters/OptimalVariantConverter.cs, 115
./csharp/Platform.Data.Doublets/Sequences/Converters/SequenceToToltsLocalElementLevelsConverter.cs, 117
./csharp/Platform.Data.Doublets/Sequences/CriterionMatchers/DefaultSequenceElementCriterionMatcher.cs, 117
./csharp/Platform.Data.Doublets/Sequences/CriterionMatchers/MarkedSequenceCriterionMatcher.cs, 118
./csharp/Platform.Data.Doublets/Sequences/DefaultSequenceAppender.cs, 118
./csharp/Platform.Data.Doublets/Sequences/DuplicateSegmentsCounter.cs, 119
./csharp/Platform.Data.Doublets/Sequences/DuplicateSegmentsProvider.cs, 119
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Cache/LinkFrequenciesCache.cs, 122
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Cache/LinkFrequency.cs, 124
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Cache/LinkToltsFrequencyValueConverter.cs, 124
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/MarkedSequenceSymbolFrequencyOneOffCounter.cs, 124
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/SequenceSymbolFrequencyOneOffCounter.cs, 125
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequencyCounter.cs, 125
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequencyOneOffCounter.cs, 126
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyCounter.cs, 126
./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyOneOffCounter.cs, 126
./csharp/Platform.Data.Doublets/Sequences/HeightProviders/CachedSequenceHeightProvider.cs, 127
./csharp/Platform.Data.Doublets/Sequences/HeightProviders/DefaultSequenceRightHeightProvider.cs, 128
./csharp/Platform.Data.Doublets/Sequences/HeightProviders/ISequenceHeightProvider.cs, 129
./csharp/Platform.Data.Doublets/Sequences/Indexes/CachedFrequencyIncrementingSequenceIndex.cs, 129
./csharp/Platform.Data.Doublets/Sequences/Indexes/FrequencyIncrementingSequenceIndex.cs, 130
./csharp/Platform.Data.Doublets/Sequences/Indexes/ISequenceIndex.cs, 130
./csharp/Platform.Data.Doublets/Sequences/Indexes/SequenceIndex.cs, 131
./csharp/Platform.Data.Doublets/Sequences/Indexes/SynchronizedSequenceIndex.cs, 131
./csharp/Platform.Data.Doublets/Sequences/Indexes/Unindex.cs, 132
./csharp/Platform.Data.Doublets/Sequences/Sequences.Experiments.cs, 132

- ./csharp/Platform.Data.Doublets/Sequences/Sequences.cs, 159
- ./csharp/Platform.Data.Doublets/Sequences/SequencesExtensions.cs, 170
- ./csharp/Platform.Data.Doublets/Sequences/SequencesOptions.cs, 171
- ./csharp/Platform.Data.Doublets/Sequences/Walkers/ISequenceWalker.cs, 173
- ./csharp/Platform.Data.Doublets/Sequences/Walkers/LeftSequenceWalker.cs, 174
- ./csharp/Platform.Data.Doublets/Sequences/Walkers/LeveledSequenceWalker.cs, 174
- ./csharp/Platform.Data.Doublets/Sequences/Walkers/RightSequenceWalker.cs, 176
- ./csharp/Platform.Data.Doublets/Sequences/Walkers/SequenceWalkerBase.cs, 176
- ./csharp/Platform.Data.Doublets/Stacks/Stack.cs, 177
- ./csharp/Platform.Data.Doublets/Stacks/StackExtensions.cs, 178
- ./csharp/Platform.Data.Doublets/SynchronizedLinks.cs, 178
- ./csharp/Platform.Data.Doublets/UInt64LinksExtensions.cs, 179
- ./csharp/Platform.Data.Doublets/UInt64LinksTransactionsLayer.cs, 181
- ./csharp/Platform.Data.Doublets/Unicode/CharToUnicodeSymbolConverter.cs, 187
- ./csharp/Platform.Data.Doublets/Unicode/StringToUnicodeSequenceConverter.cs, 187
- ./csharp/Platform.Data.Doublets/Unicode/StringToUnicodeSymbolsListConverter.cs, 188
- ./csharp/Platform.Data.Doublets/Unicode/UnicodeMap.cs, 189
- ./csharp/Platform.Data.Doublets/Unicode/UnicodeSequenceToStringConverter.cs, 191
- ./csharp/Platform.Data.Doublets/Unicode/UnicodeSymbolToCharConverter.cs, 192
- ./csharp/Platform.Data.Doublets/Unicode/UnicodeSymbolsListToUnicodeSequenceConverter.cs, 192