

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
31        [MethodImpl(MethodImplOptions.AggressiveInlining)]
32        public override TLink Update(IList<TLink> restrictions, IList<TLink> substitution) =>
33            ↪ _links.Update(restrictions, _links.ResolveConstantAsSelfReference(_constants.Itself,
34            ↪ restrictions, substitution));
35    }
36 }

```

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(IList<TLink> restrictions) => _links.CreatePoint();
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public override TLink Update(IList<TLink> restrictions, IList<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(ILinks<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public override TLink Update(IList<TLink> restrictions, IList<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(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             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/UInt32Links.cs

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
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.Decorators
8 {
9     public class UInt32Links : LinksDisposableDecoratorBase<TLink>
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt32Links(ILinks<TLink> links) : base(links) { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public override TLink Create(IList<TLink> restrictions) => _links.CreatePoint();
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public override TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
19         {
20             var constants = _constants;
21             var indexPartConstant = constants.IndexPart;
22             var sourcePartConstant = constants.SourcePart;
23             var targetPartConstant = constants.TargetPart;
```

```

24     var nullConstant = constants.Null;
25     var itselfConstant = constants.Itself;
26     var existedLink = nullConstant;
27     var updatedLink = restrictions[indexPartConstant];
28     var newSource = substitution[sourcePartConstant];
29     var newTarget = substitution[targetPartConstant];
30     var links = _links;
31     if (newSource != itselfConstant && newTarget != itselfConstant)
32     {
33         existedLink = links.SearchOrDefault(newSource, newTarget);
34     }
35     if (existedLink == nullConstant)
36     {
37         var before = links.GetLink(updatedLink);
38         if (before[sourcePartConstant] != newSource || before[targetPartConstant] !=
39             ↪ newTarget)
40         {
41             links.Update(updatedLink, newSource == itselfConstant ? updatedLink :
42                 ↪ newSource,
43                 newTarget == itselfConstant ? updatedLink :
44                     ↪ newTarget);
45         }
46         return updatedLink;
47     }
48     else
49     {
50         return _facade.MergeAndDelete(updatedLink, existedLink);
51     }
52 }
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 public override void Delete(ICollection<TLink> restrictions)
56 {
57     var linkIndex = restrictions[_constants.IndexPart];
58     var links = _links;
59     links.EnforceResetValues(linkIndex);
60     _facade.DeleteAllUsages(linkIndex);
61     links.Delete(linkIndex);
62 }
63 }

```

1.15 ./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)
23     /// + меньше объём БД
24     /// - больше сложность
25     ///
26     /// Текущее теоретическое ограничение на индекс связи, из-за использования 5 бит в размере
27     ↪ поддеревьев для AVL баланса и флагов нитей: 2 в степени(64 минус 5 равно 59 ) равно 576
28     ↪ 460 752 303 423 488
29     /// Желательно реализовать поддержку переключения между деревьями и битовыми индексами
30     ↪ (битовыми строками) - вариант матрицы (выстраиваемой лениво).
31     ///
32     /// Решить отключать ли проверки при компиляции под Release. Т.е. исключения будут
33     ↪ выбрасываться только при #if DEBUG
34     /// </remarks>
35     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] !=
57                 ↪ newTarget)
58             {
59                 links.Update(updatedLink, newSource == itselfConstant ? updatedLink :
60                     ↪ newSource,
61                                     newTarget == itselfConstant ? updatedLink :
62                     ↪ newTarget);
63             }
64             return updatedLink;
65         }
66         else
67         {
68             return _facade.MergeAndDelete(updatedLink, existedLink);
69         }
70     }
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     public override void Delete(IList<ulong> restrictions)
74     {
75         var linkIndex = restrictions[_constants.IndexPart];
76         var links = _links;
77         links.EnforceResetValues(linkIndex);
78         _facade.DeleteAllUsages(linkIndex);
79         links.Delete(linkIndex);
80     }
81 }
82
83 }

```

1.16 ./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     {

```



```

20 private static readonly EqualityComparer<TLink> _equalityComparer =
    ↳ EqualityComparer<TLink>.Default;
21
22 public UniLinks(ILinks<TLink> links) : base(links) { }
23
24 private struct Transition
25 {
26     public IList<TLink> Before;
27     public IList<TLink> After;
28
29     public Transition(IList<TLink> before, IList<TLink> after)
30     {
31         Before = before;
32         After = after;
33     }
34 }
35
36 //public static readonly TLink NullConstant = Use<LinksConstants<TLink>>.Single.Null;
37 //public static readonly IReadOnlyList<TLink> NullLink = new
    ↳ ReadOnlyCollection<TLink>(new List<TLink> { NullConstant, NullConstant, NullConstant
    ↳ });
38
39 // TODO: Подумать о том, как реализовать древовидный Restriction и Substitution
    ↳ (Links-Expression)
40 public TLink Trigger(IList<TLink> restriction, Func<IList<TLink>, IList<TLink>, TLink>
    ↳ matchedHandler, IList<TLink> substitution, Func<IList<TLink>, IList<TLink>, TLink>
    ↳ substitutedHandler)
41 {
42     /////List<Transition> transitions = null;
43     /////if (!restriction.IsNullOrEmpty())
44     /////{
45     /////    // Есть причина делать проход (чтение)
46     /////    if (matchedHandler != null)
47     /////    {
48     /////        if (!substitution.IsNullOrEmpty())
49     /////        {
50     /////            // restriction => { 0, 0, 0 } | { 0 } // Create
51     /////            // substitution => { itself, 0, 0 } | { itself, itself, itself } //
    ↳ Create / Update
52     /////            // substitution => { 0, 0, 0 } | { 0 } // Delete
53     /////            transitions = new List<Transition>();
54     /////            if (Equals(substitution[Constants.IndexPart], Constants.Null))
55     /////            {
56     /////                // If index is Null, that means we always ignore every other
    ↳ value (they are also Null by definition)
57     /////                var matchDecision = matchedHandler(, NullLink);
58     /////                if (Equals(matchDecision, Constants.Break))
59     /////                {
60     /////                    return false;
61     /////                }
62     /////                if (!Equals(matchDecision, Constants.Skip))
63     /////                {
64     /////                    transitions.Add(new Transition(matchedLink, newValue));
65     /////                }
66     /////            }
67     /////            else
68     /////            {
69     /////                Func<T, bool> handler;
70     /////                handler = link =>
71     /////                {
72     /////                    var matchedLink = Memory.GetLinkValue(link);
73     /////                    var newValue = Memory.GetLinkValue(link);
74     /////                    newValue[Constants.IndexPart] = Constants.Itself;
75     /////                    newValue[Constants.SourcePart] =
    ↳ Equals(substitution[Constants.SourcePart], Constants.Itself) ?
    ↳ matchedLink[Constants.IndexPart] : substitution[Constants.SourcePart];
76     /////                    newValue[Constants.TargetPart] =
    ↳ Equals(substitution[Constants.TargetPart], Constants.Itself) ?
    ↳ matchedLink[Constants.IndexPart] : substitution[Constants.TargetPart];
77     /////                    var matchDecision = matchedHandler(matchedLink, newValue);
78     /////                    if (Equals(matchDecision, Constants.Break))
79     /////                    {
80     /////                        return false;
81     /////                    }
82     /////                    if (!Equals(matchDecision, Constants.Skip))
83     /////                    {
84     /////                        transitions.Add(new Transition(matchedLink, newValue));
85     /////                    }
86     /////                    return true;
87     /////                };
88     /////            }
89     /////            if (!Memory.Each(handler, restriction))
90     /////            {
91     /////                return Constants.Break;
92     /////            }
93     /////        }
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```

```

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     {
151         matchedLinks = new List<IList<T>>>();
152         Func<T, bool> handler = link =>
153         {
154             var matchedLink = Memory.GetLinkValue(link);
155             var matchDecision = matchedHandler(matchedLink);
156             if (Equals(matchDecision, Constants.Break))
157                 return false;
158             if (!Equals(matchDecision, Constants.Skip))
159                 matchedLinks.Add(matchedLink);
160             return true;
161         };
162         if (!Memory.Each(handler, restriction))
163             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             }
191         }
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1000    // }

```

```

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         return constants.Continue;
300     }
301     else
302     {
303         throw new NotSupportedException();
304     }
305 }
306 }
307
308 /// <remarks>
309 /// IList[IList[IList[T]]]
310 /// |         |         |         |||

```

```

309 /// | | | | | | | | | |
310 /// | | | | | | | | | |
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315 /// | | | | | | | | | |
316 public IList<IList<IList<TLink>>> Trigger(IList<TLink> condition, IList<TLink>
    ↳ substitution)
317 {
318     var changes = new List<IList<IList<TLink>>>();
319     var @continue = _constants.Continue;
320     Trigger(condition, AlwaysContinue, substitution, (before, after) =>
321     {
322         var change = new[] { before, after };
323         changes.Add(change);
324         return @continue;
325     });
326     return changes;
327 }
328
329 private TLink AlwaysContinue(IList<TLink> linkToMatch) => _constants.Continue;
330 }
331 }

```

1.17 ./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         public readonly T Target;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public Doublet(T source, T target)
19         {
20             Source = source;
21             Target = target;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public override string ToString() => $"{Source}->{Target}";
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         public bool Equals(Doublet<T> other) => _equalityComparer.Equals(Source, other.Source)
29             ↳ && _equalityComparer.Equals(Target, other.Target);
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public override bool Equals(object obj) => obj is Doublet<T> doublet ?
33             ↳ base.Equals(doublet) : false;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         public override int GetHashCode() => (Source, Target).GetHashCode();
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         public static bool operator ==(Doublet<T> left, Doublet<T> right) => left.Equals(right);
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         public static bool operator !=(Doublet<T> left, Doublet<T> right) => !(left == right);
43     }
44 }

```

1.18 ./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 }

```

1.19 ./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 }

```

1.20 ./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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         public static void RunRandomSearches<TLink>(this ILinks<TLink> links, ulong
42             ↳ amountOfSearches)
43         {
44             var random = RandomHelpers.Default;
45             var addressToUInt64Converter = UncheckedConverter<TLink, ulong>.Default;
46             var uInt64ToAddressConverter = UncheckedConverter<ulong, TLink>.Default;
47             for (var i = 0UL; i < amountOfSearches; i++)
48             {
49                 var linksAddressRange = new Range<ulong>(0,
50                     ↳ addressToUInt64Converter.Convert(links.Count()));

```

```

45     var source =
46         ↪ uInt64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
47     var target =
48         ↪ uInt64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
49     links.SearchOrDefault(source, target);
50 }
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 public static void RunRandomDeletions<TLink>(this ILinks<TLink> links, ulong
53     ↪ amountOfDeletions)
54 {
55     var random = RandomHelpers.Default;
56     var addressToUInt64Converter = UncheckedConverter<TLink, ulong>.Default;
57     var uInt64ToAddressConverter = UncheckedConverter<ulong, TLink>.Default;
58     var linksCount = addressToUInt64Converter.Convert(links.Count());
59     var min = amountOfDeletions > linksCount ? OUL : linksCount - amountOfDeletions;
60     for (var i = OUL; i < amountOfDeletions; i++)
61     {
62         linksCount = addressToUInt64Converter.Convert(links.Count());
63         if (linksCount <= min)
64         {
65             break;
66         }
67         var linksAddressRange = new Range<ulong>(min, linksCount);
68         var link =
69             ↪ uInt64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
70         links.Delete(link);
71     }
72 }
73 [MethodImpl(MethodImplOptions.AggressiveInlining)]
74 public static void Delete<TLink>(this ILinks<TLink> links, TLink linkToDelete) =>
75     ↪ links.Delete(new LinkAddress<TLink>(linkToDelete));
76
77 /// <remarks>
78 /// TODO0: Возможно есть очень простой способ это сделать.
79 /// (Например просто удалить файл, или изменить его размер таким образом,
80 /// чтобы удалился весь контент)
81 /// Например через _header->AllocatedLinks в ResizableDirectMemoryLinks
82 /// </remarks>
83 [MethodImpl(MethodImplOptions.AggressiveInlining)]
84 public static void DeleteAll<TLink>(this ILinks<TLink> links)
85 {
86     var equalityComparer = EqualityComparer<TLink>.Default;
87     var comparer = Comparer<TLink>.Default;
88     for (var i = links.Count(); comparer.Compare(i, default) > 0; i =
89         ↪ Arithmetic.Decrement(i))
90     {
91         links.Delete(i);
92         if (!equalityComparer.Equals(links.Count(), Arithmetic.Decrement(i)))
93         {
94             i = links.Count();
95         }
96     }
97 }
98
99 [MethodImpl(MethodImplOptions.AggressiveInlining)]
100 public static TLink First<TLink>(this ILinks<TLink> links)
101 {
102     TLink firstLink = default;
103     var equalityComparer = EqualityComparer<TLink>.Default;
104     if (equalityComparer.Equals(links.Count(), default))
105     {
106         throw new InvalidOperationException("В хранилище нет связей.");
107     }
108     links.Each(links.Constants.Any, links.Constants.Any, link =>
109     {
110         firstLink = link[links.Constants.IndexPart];
111         return links.Constants.Break;
112     });
113     if (equalityComparer.Equals(firstLink, default))
114     {
115         throw new InvalidOperationException("В процессе поиска по хранилищу не было
116             ↪ найдено связей.");
117     }
118     return firstLink;
119 }

```

```

116 [MethodImpl(MethodImplOptions.AggressiveInlining)]
117 public static IList<TLink> SingleOrDefault<TLink>(this ILinks<TLink> links, IList<TLink>
118     ↪ query)
119 {
120     IList<TLink> result = null;
121     var count = 0;
122     var constants = links.Constants;
123     var @continue = constants.Continue;
124     var @break = constants.Break;
125     links.Each(linkHandler, query);
126     return result;
127
128     TLink linkHandler(IList<TLink> link)
129     {
130         if (count == 0)
131         {
132             result = link;
133             count++;
134             return @continue;
135         }
136         else
137         {
138             result = null;
139             return @break;
140         }
141     }
142 }
143
144 #region Paths
145
146 /// <remarks>
147 /// TODO: Как так? Как то что ниже может быть корректно?
148 /// Скорее всего практически не применимо
149 /// Предполагалось, что можно было конвертировать формируемый в проходе через
150     ↪ SequenceWalker
151 /// Stack в конкретный путь из Source, Target до связи, но это не всегда так.
152 /// TODO: Возможно нужен метод, который именно выбрасывает исключения (EnsurePathExists)
153 /// </remarks>
154 [MethodImpl(MethodImplOptions.AggressiveInlining)]
155 public static bool CheckPathExistance<TLink>(this ILinks<TLink> links, params TLink[]
156     ↪ path)
157 {
158     var current = path[0];
159     //EnsureLinkExists(current, "path");
160     if (!links.Exists(current))
161     {
162         return false;
163     }
164     var equalityComparer = EqualityComparer<TLink>.Default;
165     var constants = links.Constants;
166     for (var i = 1; i < path.Length; i++)
167     {
168         var next = path[i];
169         var values = links.GetLink(current);
170         var source = values[constants.SourcePart];
171         var target = values[constants.TargetPart];
172         if (equalityComparer.Equals(source, target) && equalityComparer.Equals(source,
173             ↪ next))
174         {
175             //throw new InvalidOperationException(string.Format("Невозможно выбрать
176             ↪ путь, так как и Source и Target совпадают с элементом пути {0}.", next));
177             return false;
178         }
179         if (!equalityComparer.Equals(next, source) && !equalityComparer.Equals(next,
180             ↪ target))
181         {
182             //throw new InvalidOperationException(string.Format("Невозможно продолжить
183             ↪ путь через элемент пути {0}", next));
184             return false;
185         }
186         current = next;
187     }
188     return true;
189 }
190
191 /// <remarks>
192 /// Может потребовать дополнительного стека для PathElement's при использовании
193     ↪ SequenceWalker.

```



```

187 /// </remarks>
188 [MethodImpl(MethodImplOptions.AggressiveInlining)]
189 public static TLink GetByKeys<TLink>(this ILinks<TLink> links, TLink root, params int[]
    ↳ path)
190 {
191     links.EnsureLinkExists(root, "root");
192     var currentLink = root;
193     for (var i = 0; i < path.Length; i++)
194     {
195         currentLink = links.GetLink(currentLink)[path[i]];
196     }
197     return currentLink;
198 }
199
200 [MethodImpl(MethodImplOptions.AggressiveInlining)]
201 public static TLink GetSquareMatrixSequenceElementByIndex<TLink>(this ILinks<TLink>
    ↳ links, TLink root, ulong size, ulong index)
202 {
203     var constants = links.Constants;
204     var source = constants.SourcePart;
205     var target = constants.TargetPart;
206     if (!Platform.Numbers.Math.IsPowerOfTwo(size))
207     {
208         throw new ArgumentOutOfRangeException(nameof(size), "Sequences with sizes other
            ↳ than powers of two are not supported.");
209     }
210     var path = new BitArray(BitConverter.GetBytes(index));
211     var length = Bit.GetLowestPosition(size);
212     links.EnsureLinkExists(root, "root");
213     var currentLink = root;
214     for (var i = length - 1; i >= 0; i--)
215     {
216         currentLink = links.GetLink(currentLink)[path[i] ? target : source];
217     }
218     return currentLink;
219 }
220
221 #endregion
222
223 /// <summary>
224 /// Возвращает индекс указанной связи.
225 /// </summary>
226 /// <param name="links">Хранилище связей.</param>
227 /// <param name="link">Связь представленная списком, состоящим из её адреса и
    ↳ содержимого.</param>
228 /// <returns>Индекс начальной связи для указанной связи.</returns>
229 [MethodImpl(MethodImplOptions.AggressiveInlining)]
230 public static TLink GetIndex<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
    ↳ link[links.Constants.IndexPart];
231
232 /// <summary>
233 /// Возвращает индекс начальной (Source) связи для указанной связи.
234 /// </summary>
235 /// <param name="links">Хранилище связей.</param>
236 /// <param name="link">Индекс связи.</param>
237 /// <returns>Индекс начальной связи для указанной связи.</returns>
238 [MethodImpl(MethodImplOptions.AggressiveInlining)]
239 public static TLink GetSource<TLink>(this ILinks<TLink> links, TLink link) =>
    ↳ links.GetLink(link)[links.Constants.SourcePart];
240
241 /// <summary>
242 /// Возвращает индекс начальной (Source) связи для указанной связи.
243 /// </summary>
244 /// <param name="links">Хранилище связей.</param>
245 /// <param name="link">Связь представленная списком, состоящим из её адреса и
    ↳ содержимого.</param>
246 /// <returns>Индекс начальной связи для указанной связи.</returns>
247 [MethodImpl(MethodImplOptions.AggressiveInlining)]
248 public static TLink GetSource<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
    ↳ link[links.Constants.SourcePart];
249
250 /// <summary>
251 /// Возвращает индекс конечной (Target) связи для указанной связи.
252 /// </summary>
253 /// <param name="links">Хранилище связей.</param>
254 /// <param name="link">Индекс связи.</param>
255 /// <returns>Индекс конечной связи для указанной связи.</returns>
256 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

257 public static TLink GetTarget<TLink>(this ILinks<TLink> links, TLink link) =>
258     ↳ links.GetLink(link)[links.Constants.TargetPart];
259
260 /// <summary>
261 /// Возвращает индекс конечной (Target) связи для указанной связи.
262 /// </summary>
263 /// <param name="links">Хранилище связей.</param>
264 /// <param name="link">Связь представленная списком, состоящим из её адреса и
265     ↳ содержимого.</param>
266 /// <returns>Индекс конечной связи для указанной связи.</returns>
267 [MethodImpl(MethodImplOptions.AggressiveInlining)]
268 public static TLink GetTarget<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
269     ↳ link[links.Constants.TargetPart];
270
271 /// <summary>
272 /// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
273     ↳ (handler) для каждой подходящей связи.
274 /// </summary>
275 /// <param name="links">Хранилище связей.</param>
276 /// <param name="handler">Обработчик каждой подходящей связи.</param>
277 /// <param name="restrictions">Ограничения на содержимое связей. Каждое ограничение
278     ↳ может иметь значения: Constants.Null - 0-я связь, обозначающая ссылку на пустоту,
279     ↳ Any - отсутствие ограничения, 1..∞ конкретный адрес связи.</param>
280 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
281     ↳ случае.</returns>
282 [MethodImpl(MethodImplOptions.AggressiveInlining)]
283 public static bool Each<TLink>(this ILinks<TLink> links, Func<IList<TLink>, TLink>
284     ↳ handler, params TLink[] restrictions)
285     => EqualityComparer<TLink>.Default.Equals(links.Each(handler, restrictions),
286     ↳ links.Constants.Continue);
287
288 /// <summary>
289 /// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
290     ↳ (handler) для каждой подходящей связи.
291 /// </summary>
292 /// <param name="links">Хранилище связей.</param>
293 /// <param name="source">Значение, определяющее соответствующие шаблону связи.
294     ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве начала,
295     ↳ Constants.Any - любое начало, 1..∞ конкретное начало)</param>
296 /// <param name="target">Значение, определяющее соответствующие шаблону связи.
297     ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве конца,
298     ↳ Constants.Any - любой конец, 1..∞ конкретный конец)</param>
299 /// <param name="handler">Обработчик каждой подходящей связи.</param>
300 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
301     ↳ случае.</returns>
302 [MethodImpl(MethodImplOptions.AggressiveInlining)]
303 public static bool Each<TLink>(this ILinks<TLink> links, TLink source, TLink target,
304     ↳ Func<TLink, bool> handler)
305 {
306     var constants = links.Constants;
307     return links.Each(link => handler(link[constants.IndexPart]) ? constants.Continue :
308     ↳ constants.Break, constants.Any, source, target);
309 }
310
311 /// <summary>
312 /// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
313     ↳ (handler) для каждой подходящей связи.
314 /// </summary>
315 /// <param name="links">Хранилище связей.</param>
316 /// <param name="source">Значение, определяющее соответствующие шаблону связи.
317     ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве начала,
318     ↳ Constants.Any - любое начало, 1..∞ конкретное начало)</param>
319 /// <param name="target">Значение, определяющее соответствующие шаблону связи.
320     ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве конца,
321     ↳ Constants.Any - любой конец, 1..∞ конкретный конец)</param>
322 /// <param name="handler">Обработчик каждой подходящей связи.</param>
323 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
324     ↳ случае.</returns>
325 [MethodImpl(MethodImplOptions.AggressiveInlining)]
326 public static bool Each<TLink>(this ILinks<TLink> links, TLink source, TLink target,
327     ↳ Func<IList<TLink>, TLink> handler) => links.Each(handler, links.Constants.Any,
328     ↳ source, target);
329
330 [MethodImpl(MethodImplOptions.AggressiveInlining)]
331 public static IList<IList<TLink>> All<TLink>(this ILinks<TLink> links, params TLink[]
332     ↳ restrictions)

```

```

307 {
308     var arraySize = CheckedConverter<TLink,
        ↳ ulong>.Default.Convert(links.Count(restrictions));
309     if (arraySize > 0)
310     {
311         var array = new IList<TLink>[arraySize];
312         var filler = new ArrayFiller<IList<TLink>, TLink>(array,
        ↳ links.Constants.Continue);
313         links.Each(filler.AddAndReturnConstant, restrictions);
314         return array;
315     }
316     else
317     {
318         return Array.Empty<IList<TLink>>();
319     }
320 }
321
322 [MethodImpl(MethodImplOptions.AggressiveInlining)]
323 public static IList<TLink> AllIndices<TLink>(this ILinks<TLink> links, params TLink[]
        ↳ restrictions)
324 {
325     var arraySize = CheckedConverter<TLink,
        ↳ ulong>.Default.Convert(links.Count(restrictions));
326     if (arraySize > 0)
327     {
328         var array = new TLink[arraySize];
329         var filler = new ArrayFiller<TLink, TLink>(array, links.Constants.Continue);
330         links.Each(filler.AddFirstAndReturnConstant, restrictions);
331         return array;
332     }
333     else
334     {
335         return Array.Empty<TLink>();
336     }
337 }
338
339 /// <summary>
340 /// Возвращает значение, определяющее существует ли связь с указанными началом и концом
        ↳ в хранилище связей.
341 /// </summary>
342 /// <param name="links">Хранилище связей.</param>
343 /// <param name="source">Начало связи.</param>
344 /// <param name="target">Конец связи.</param>
345 /// <returns>Значение, определяющее существует ли связь.</returns>
346 [MethodImpl(MethodImplOptions.AggressiveInlining)]
347 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;
348
349 #region Ensure
350 // TODO: May be move to EnsureExtensions or make it both there and here
351
352 [MethodImpl(MethodImplOptions.AggressiveInlining)]
353 public static void EnsureLinkExists<TLink>(this ILinks<TLink> links, IList<TLink>
        ↳ restrictions)
354 {
355     for (var i = 0; i < restrictions.Count; i++)
356     {
357         if (!links.Exists(restrictions[i]))
358         {
359             throw new ArgumentLinkDoesNotExistsException<TLink>(restrictions[i],
        ↳ $"sequence[{i}]");
360         }
361     }
362 }
363
364 [MethodImpl(MethodImplOptions.AggressiveInlining)]
365 public static void EnsureInnerReferenceExists<TLink>(this ILinks<TLink> links, TLink
        ↳ reference, string argumentName)
366 {
367     if (links.Constants.IsInternalReference(reference) && !links.Exists(reference))
368     {
369         throw new ArgumentLinkDoesNotExistsException<TLink>(reference, argumentName);
370     }
371 }
372
373 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

374 public static void EnsureInnerReferenceExists<TLink>(this ILinks<TLink> links,
    ↳ IList<TLink> restrictions, string argumentName)
375 {
376     for (int i = 0; i < restrictions.Count; i++)
377     {
378         links.EnsureInnerReferenceExists(restrictions[i], argumentName);
379     }
380 }
381
382 [MethodImpl(MethodImplOptions.AggressiveInlining)]
383 public static void EnsureLinkIsAnyOrExists<TLink>(this ILinks<TLink> links, IList<TLink>
    ↳ restrictions)
384 {
385     var equalityComparer = EqualityComparer<TLink>.Default;
386     var any = links.Constants.Any;
387     for (var i = 0; i < restrictions.Count; i++)
388     {
389         if (!equalityComparer.Equals(restrictions[i], any) &&
            ↳ !links.Exists(restrictions[i]))
390         {
391             throw new ArgumentLinkDoesNotExistsException<TLink>(restrictions[i],
                ↳ $"{sequence[{i}]"}");
392         }
393     }
394 }
395
396 [MethodImpl(MethodImplOptions.AggressiveInlining)]
397 public static void EnsureLinkIsAnyOrExists<TLink>(this ILinks<TLink> links, TLink link,
    ↳ string argumentName)
398 {
399     var equalityComparer = EqualityComparer<TLink>.Default;
400     if (!equalityComparer.Equals(link, links.Constants.Any) && !links.Exists(link))
401     {
402         throw new ArgumentLinkDoesNotExistsException<TLink>(link, argumentName);
403     }
404 }
405
406 [MethodImpl(MethodImplOptions.AggressiveInlining)]
407 public static void EnsureLinkIsItselfOrExists<TLink>(this ILinks<TLink> links, TLink
    ↳ link, string argumentName)
408 {
409     var equalityComparer = EqualityComparer<TLink>.Default;
410     if (!equalityComparer.Equals(link, links.Constants.Itself) && !links.Exists(link))
411     {
412         throw new ArgumentLinkDoesNotExistsException<TLink>(link, argumentName);
413     }
414 }
415
416 /// <param name="links">Хранилище связей.</param>
417 [MethodImpl(MethodImplOptions.AggressiveInlining)]
418 public static void EnsureDoesNotExists<TLink>(this ILinks<TLink> links, TLink source,
    ↳ TLink target)
419 {
420     if (links.Exists(source, target))
421     {
422         throw new LinkWithSameValueAlreadyExistsException();
423     }
424 }
425
426 /// <param name="links">Хранилище связей.</param>
427 [MethodImpl(MethodImplOptions.AggressiveInlining)]
428 public static void EnsureNoUsages<TLink>(this ILinks<TLink> links, TLink link)
429 {
430     if (links.HasUsages(link))
431     {
432         throw new ArgumentLinkHasDependenciesException<TLink>(link);
433     }
434 }
435
436 /// <param name="links">Хранилище связей.</param>
437 [MethodImpl(MethodImplOptions.AggressiveInlining)]
438 public static void EnsureCreated<TLink>(this ILinks<TLink> links, params TLink[]
    ↳ addresses) => links.EnsureCreated(links.Create, addresses);
439
440 /// <param name="links">Хранилище связей.</param>
441 [MethodImpl(MethodImplOptions.AggressiveInlining)]
442 public static void EnsurePointsCreated<TLink>(this ILinks<TLink> links, params TLink[]
    ↳ addresses) => links.EnsureCreated(links.CreatePoint, addresses);

```

```

443
444 /// <param name="links">Хранилище связей.</param>
445 [MethodImpl(MethodImplOptions.AggressiveInlining)]
446 public static void EnsureCreated<TLink>(this ILinks<TLink> links, Func<TLink> creator,
    ↪ params TLink[] addresses)
447 {
448     var addressToUInt64Converter = CheckedConverter<TLink, ulong>.Default;
449     var uInt64ToAddressConverter = CheckedConverter<ulong, TLink>.Default;
450     var nonExistentAddresses = new HashSet<TLink>(addresses.Where(x =>
    ↪ !links.Exists(x)));
451     if (nonExistentAddresses.Count > 0)
452     {
453         var max = nonExistentAddresses.Max();
454         max = uInt64ToAddressConverter.Convert(System.Math.Min(addressToUInt64Converter.
    ↪ Convert(max),
    ↪ addressToUInt64Converter.Convert(links.Constants.InternalReferencesRange.Max
    ↪ imum)));
455         var createdLinks = new List<TLink>();
456         var equalityComparer = EqualityComparer<TLink>.Default;
457         TLink createdLink = creator();
458         while (!equalityComparer.Equals(createdLink, max))
459         {
460             createdLinks.Add(createdLink);
461         }
462         for (var i = 0; i < createdLinks.Count; i++)
463         {
464             if (!nonExistentAddresses.Contains(createdLinks[i]))
465             {
466                 links.Delete(createdLinks[i]);
467             }
468         }
469     }
470 }
471
472 #endregion
473
474 /// <param name="links">Хранилище связей.</param>
475 [MethodImpl(MethodImplOptions.AggressiveInlining)]
476 public static TLink CountUsages<TLink>(this ILinks<TLink> links, TLink link)
477 {
478     var constants = links.Constants;
479     var values = links.GetLink(link);
480     TLink usagesAsSource = links.Count(new Link<TLink>(constants.Any, link,
    ↪ constants.Any));
481     var equalityComparer = EqualityComparer<TLink>.Default;
482     if (equalityComparer.Equals(values[constants.SourcePart], link))
483     {
484         usagesAsSource = Arithmetic<TLink>.Decrement(usagesAsSource);
485     }
486     TLink usagesAsTarget = links.Count(new Link<TLink>(constants.Any, constants.Any,
    ↪ link));
487     if (equalityComparer.Equals(values[constants.TargetPart], link))
488     {
489         usagesAsTarget = Arithmetic<TLink>.Decrement(usagesAsTarget);
490     }
491     return Arithmetic<TLink>.Add(usagesAsSource, usagesAsTarget);
492 }
493
494 /// <param name="links">Хранилище связей.</param>
495 [MethodImpl(MethodImplOptions.AggressiveInlining)]
496 public static bool HasUsages<TLink>(this ILinks<TLink> links, TLink link) =>
    ↪ Comparer<TLink>.Default.Compare(links.CountUsages(link), default) > 0;
497
498 /// <param name="links">Хранилище связей.</param>
499 [MethodImpl(MethodImplOptions.AggressiveInlining)]
500 public static bool Equals<TLink>(this ILinks<TLink> links, TLink link, TLink source,
    ↪ TLink target)
501 {
502     var constants = links.Constants;
503     var values = links.GetLink(link);
504     var equalityComparer = EqualityComparer<TLink>.Default;
505     return equalityComparer.Equals(values[constants.SourcePart], source) &&
    ↪ equalityComparer.Equals(values[constants.TargetPart], target);
506 }
507
508 /// <summary>
509 /// Выполняет поиск связи с указанными Source (началом) и Target (концом).
510 /// </summary>

```

```

511 /// <param name="links">Хранилище связей.</param>
512 /// <param name="source">Индекс связи, которая является началом для искомой
513 → связи.</param>
514 /// <param name="target">Индекс связи, которая является концом для искомой связи.</param>
515 /// <returns>Индекс искомой связи с указанными Source (началом) и Target
516 → (концом).</returns>
517 [MethodImpl(MethodImplOptions.AggressiveInlining)]
518 public static TLink SearchOrDefault<TLink>(this ILinks<TLink> links, TLink source, TLink
519 → target)
520 {
521     var constants = links.Constants;
522     var setter = new Setter<TLink, TLink>(constants.Continue, constants.Break, default);
523     links.Each(setter.SetFirstAndReturnFalse, constants.Any, source, target);
524     return setter.Result;
525 }
526 /// <param name="links">Хранилище связей.</param>
527 [MethodImpl(MethodImplOptions.AggressiveInlining)]
528 public static TLink Create<TLink>(this ILinks<TLink> links) => links.Create(null);
529 /// <param name="links">Хранилище связей.</param>
530 [MethodImpl(MethodImplOptions.AggressiveInlining)]
531 public static TLink CreatePoint<TLink>(this ILinks<TLink> links)
532 {
533     var link = links.Create();
534     return links.Update(link, link, link);
535 }
536 /// <param name="links">Хранилище связей.</param>
537 [MethodImpl(MethodImplOptions.AggressiveInlining)]
538 public static TLink CreateAndUpdate<TLink>(this ILinks<TLink> links, TLink source, TLink
539 → target) => links.Update(links.Create(), source, target);
540 /// <summary>
541 /// Обновляет связь с указанными началом (Source) и концом (Target)
542 /// на связь с указанными началом (NewSource) и концом (NewTarget).
543 /// </summary>
544 /// <param name="links">Хранилище связей.</param>
545 /// <param name="link">Индекс обновляемой связи.</param>
546 /// <param name="newSource">Индекс связи, которая является началом связи, на которую
547 → выполняется обновление.</param>
548 /// <param name="newTarget">Индекс связи, которая является концом связи, на которую
549 → выполняется обновление.</param>
550 /// <returns>Индекс обновлённой связи.</returns>
551 [MethodImpl(MethodImplOptions.AggressiveInlining)]
552 public static TLink Update<TLink>(this ILinks<TLink> links, TLink link, TLink newSource,
553 → TLink newTarget) => links.Update(new LinkAddress<TLink>(link), new Link<TLink>(link,
554 → newSource, newTarget));
555 /// <summary>
556 /// Обновляет связь с указанными началом (Source) и концом (Target)
557 /// на связь с указанными началом (NewSource) и концом (NewTarget).
558 /// </summary>
559 /// <param name="links">Хранилище связей.</param>
560 /// <param name="restrictions">Ограничения на содержимое связей. Каждое ограничение
561 → может иметь значения: Constants.Null - 0-я связь, обозначающая ссылку на пустоту,
562 → Itself - требование установить ссылку на себя, 1..∞ конкретный адрес другой
563 → связи.</param>
564 /// <returns>Индекс обновлённой связи.</returns>
565 [MethodImpl(MethodImplOptions.AggressiveInlining)]
566 public static TLink Update<TLink>(this ILinks<TLink> links, params TLink[] restrictions)
567 {
568     if (restrictions.Length == 2)
569     {
570         return links.MergeAndDelete(restrictions[0], restrictions[1]);
571     }
572     if (restrictions.Length == 4)
573     {
574         return links.UpdateOrCreateOrGet(restrictions[0], restrictions[1],
575 → restrictions[2], restrictions[3]);
576     }
577     else
578     {
579         return links.Update(new LinkAddress<TLink>(restrictions[0]), restrictions);
580     }
581 }
582 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

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

```

```

644 {
645     var link = links.SearchOrDefault(source, target);
646     if (!EqualityComparer<TLink>.Default.Equals(link, default))
647     {
648         links.Delete(link);
649         return link;
650     }
651     return default;
652 }
653
654 /// <summary>Удаляет несколько связей.</summary>
655 /// <param name="links">Хранилище связей.</param>
656 /// <param name="deletedLinks">Список адресов связей к удалению.</param>
657 [MethodImpl(MethodImplOptions.AggressiveInlining)]
658 public static void DeleteMany<TLink>(this ILinks<TLink> links, IList<TLink> deletedLinks)
659 {
660     for (int i = 0; i < deletedLinks.Count; i++)
661     {
662         links.Delete(deletedLinks[i]);
663     }
664 }
665
666 /// <remarks>Before execution of this method ensure that deleted link is detached (all
667   ↳ values - source and target are reset to null) or it might enter into infinite
668   ↳ recursion.</remarks>
669 [MethodImpl(MethodImplOptions.AggressiveInlining)]
670 public static void DeleteAllUsages<TLink>(this ILinks<TLink> links, TLink linkIndex)
671 {
672     var anyConstant = links.Constants.Any;
673     var usagesAsSourceQuery = new Link<TLink>(anyConstant, linkIndex, anyConstant);
674     links.DeleteByQuery(usagesAsSourceQuery);
675     var usagesAsTargetQuery = new Link<TLink>(anyConstant, linkIndex, anyConstant);
676     links.DeleteByQuery(usagesAsTargetQuery);
677 }
678
679 [MethodImpl(MethodImplOptions.AggressiveInlining)]
680 public static void DeleteByQuery<TLink>(this ILinks<TLink> links, Link<TLink> query)
681 {
682     var count = CheckedConverter<TLink, long>.Default.Convert(links.Count(query));
683     if (count > 0)
684     {
685         var queryResult = new TLink[count];
686         var queryResultFiller = new ArrayFiller<TLink, TLink>(queryResult,
687   ↳ links.Constants.Continue);
688         links.Each(queryResultFiller.AddFirstAndReturnConstant, query);
689         for (var i = count - 1; i >= 0; i--)
690         {
691             links.Delete(queryResult[i]);
692         }
693     }
694 }
695
696 // TODO: Move to Platform.Data
697 [MethodImpl(MethodImplOptions.AggressiveInlining)]
698 public static bool AreValuesReset<TLink>(this ILinks<TLink> links, TLink linkIndex)
699 {
700     var nullConstant = links.Constants.Null;
701     var equalityComparer = EqualityComparer<TLink>.Default;
702     var link = links.GetLink(linkIndex);
703     for (int i = 1; i < link.Count; i++)
704     {
705         if (!equalityComparer.Equals(link[i], nullConstant))
706         {
707             return false;
708         }
709     }
710     return true;
711 }
712
713 // TODO: Create a universal version of this method in Platform.Data (with using of for
714   ↳ loop)
715 [MethodImpl(MethodImplOptions.AggressiveInlining)]
716 public static void ResetValues<TLink>(this ILinks<TLink> links, TLink linkIndex)
717 {
718     var nullConstant = links.Constants.Null;
719     var updateRequest = new Link<TLink>(linkIndex, nullConstant, nullConstant);
720     links.Update(updateRequest);
721 }

```



```

718 // TODO: Create a universal version of this method in Platform.Data (with using of for
719 ↪ loop)
720 [MethodImpl(MethodImplOptions.AggressiveInlining)]
721 public static void EnforceResetValues<TLink>(this ILinks<TLink> links, TLink linkIndex)
722 {
723     if (!links.AreValuesReset(linkIndex))
724     {
725         links.ResetValues(linkIndex);
726     }
727 }
728
729 /// <summary>
730 /// Merging two usages graphs, all children of old link moved to be children of new link
731 ↪ or deleted.
732 /// </summary>
733 [MethodImpl(MethodImplOptions.AggressiveInlining)]
734 public static TLink MergeUsages<TLink>(this ILinks<TLink> links, TLink oldLinkIndex,
735 ↪ TLink newLinkIndex)
736 {
737     var addressToInt64Converter = CheckedConverter<TLink, long>.Default;
738     var equalityComparer = EqualityComparer<TLink>.Default;
739     if (!equalityComparer.Equals(oldLinkIndex, newLinkIndex))
740     {
741         var constants = links.Constants;
742         var usagesAsSourceQuery = new Link<TLink>(constants.Any, oldLinkIndex,
743 ↪ constants.Any);
744         var usagesAsSourceCount =
745 ↪ addressToInt64Converter.Convert(links.Count(usagesAsSourceQuery));
746         var usagesAsTargetQuery = new Link<TLink>(constants.Any, constants.Any,
747 ↪ oldLinkIndex);
748         var usagesAsTargetCount =
749 ↪ addressToInt64Converter.Convert(links.Count(usagesAsTargetQuery));
750         var isStandalonePoint = Point<TLink>.IsFullPoint(links.GetLink(oldLinkIndex)) &&
751 ↪ usagesAsSourceCount == 1 && usagesAsTargetCount == 1;
752         if (!isStandalonePoint)
753         {
754             var totalUsages = usagesAsSourceCount + usagesAsTargetCount;
755             if (totalUsages > 0)
756             {
757                 var usages = ArrayPool.Allocate<TLink>(totalUsages);
758                 var usagesFiller = new ArrayFiller<TLink, TLink>(usages,
759 ↪ links.Constants.Continue);
760                 var i = 0L;
761                 if (usagesAsSourceCount > 0)
762                 {
763                     links.Each(usagesFiller.AddFirstAndReturnConstant,
764 ↪ usagesAsSourceQuery);
765                     for (; i < usagesAsSourceCount; i++)
766                     {
767                         var usage = usages[i];
768                         if (!equalityComparer.Equals(usage, oldLinkIndex))
769                         {
770                             links.Update(usage, newLinkIndex, links.GetTarget(usage));
771                         }
772                     }
773                 }
774                 if (usagesAsTargetCount > 0)
775                 {
776                     links.Each(usagesFiller.AddFirstAndReturnConstant,
777 ↪ usagesAsTargetQuery);
778                     for (; i < usages.Length; i++)
779                     {
780                         var usage = usages[i];
781                         if (!equalityComparer.Equals(usage, oldLinkIndex))
782                         {
783                             links.Update(usage, links.GetSource(usage), newLinkIndex);
784                         }
785                     }
786                 }
787                 ArrayPool.Free(usages);
788             }
789         }
790     }
791     return newLinkIndex;
792 }
793
794 /// <summary>

```

```

785     /// Replace one link with another (replaced link is deleted, children are updated or
    ↪ deleted).
786     /// </summary>
787     [MethodImpl(MethodImplOptions.AggressiveInlining)]
788     public static TLink MergeAndDelete<TLink>(this ILinks<TLink> links, TLink oldLinkIndex,
    ↪ TLink newLinkIndex)
789     {
790         var equalityComparer = EqualityComparer<TLink>.Default;
791         if (!equalityComparer.Equals(oldLinkIndex, newLinkIndex))
792         {
793             links.MergeUsages(oldLinkIndex, newLinkIndex);
794             links.Delete(oldLinkIndex);
795         }
796         return newLinkIndex;
797     }
798
799     [MethodImpl(MethodImplOptions.AggressiveInlining)]
800     public static ILinks<TLink>
    ↪ DecorateWithAutomaticUniquenessAndUsagesResolution<TLink>(this ILinks<TLink> links)
801     {
802         links = new LinksCascadeUsagesResolver<TLink>(links);
803         links = new NonNullContentsLinkDeletionResolver<TLink>(links);
804         links = new LinksCascadeUniquenessAndUsagesResolver<TLink>(links);
805         return links;
806     }
807
808     [MethodImpl(MethodImplOptions.AggressiveInlining)]
809     public static string Format<TLink>(this ILinks<TLink> links, IList<TLink> link)
810     {
811         var constants = links.Constants;
812         return $"({link[constants.IndexPart]}: {link[constants.SourcePart]}
    ↪ {link[constants.TargetPart]});";
813     }
814
815     [MethodImpl(MethodImplOptions.AggressiveInlining)]
816     public static string Format<TLink>(this ILinks<TLink> links, TLink link) =>
    ↪ links.Format(links.GetLink(link));
817 }
818 }

```

1.21 ./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  }

```

1.22 ./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)
19             : base(links)
20         {
21             _frequencyMarker = frequencyMarker;
22             _unaryOne = unaryOne;
23             _unaryNumberIncrementer = unaryNumberIncrementer;
24         }
25     }

```

```

26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     public TLink Increment(TLink frequency)
28     {
29         var links = _links;
30         if (_equalityComparer.Equals(frequency, default))
31         {
32             return links.GetOrCreate(_unaryOne, _frequencyMarker);
33         }
34         var incrementedSource =
35             ↪ _unaryNumberIncrementer.Increment(links.GetSource(frequency));
36         return links.GetOrCreate(incrementedSource, _frequencyMarker);
37     }
38 }

```

1.23 ./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 }

```

1.24 ./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     }
24 }

```

```

22 private static readonly EqualityComparer<TLink> _equalityComparer =
    ↳ EqualityComparer<TLink>.Default;
23
24 private const int Length = 3;
25
26 public readonly TLink Index;
27 public readonly TLink Source;
28 public readonly TLink Target;
29
30 [MethodImpl(MethodImplOptions.AggressiveInlining)]
31 public Link(params TLink[] values) => SetValues(values, out Index, out Source, out
    ↳ Target);
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;

```

```

    }
}

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public override int GetHashCode() => (Index, Source, Target).GetHashCode();

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public bool IsNull() => _equalityComparer.Equals(Index, _constants.Null)
    && _equalityComparer.Equals(Source, _constants.Null)
    && _equalityComparer.Equals(Target, _constants.Null);

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public override bool Equals(object other) => other is Link<TLink> &&
    => Equals((Link<TLink>)other);

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public bool Equals(Link<TLink> other) => _equalityComparer.Equals(Index, other.Index)
    && _equalityComparer.Equals(Source, other.Source)
    && _equalityComparer.Equals(Target, other.Target);

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static string ToString(TLink index, TLink source, TLink target) => $"{index}:
    ↳ {source}->{target}";

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static string ToString(TLink source, TLink target) => $"{source}->{target}";

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static implicit operator TLink[] (Link<TLink> link) => link.ToArray();

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static implicit operator Link<TLink>(TLink[] linkArray) => new
    ↳ Link<TLink>(linkArray);

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public override string ToString() => _equalityComparer.Equals(Index, _constants.Null) ?
    ↳ ToString(Source, Target) : ToString(Index, Source, Target);

#region IList

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

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

public TLink this[int index]
{
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    get
    {
        Ensure.OnDebug.ArgumentInRange(index, new Range<int>(0, Length - 1),
            ↳ nameof(index));
        if (index == _constants.IndexPart)
        {
            return Index;
        }
        if (index == _constants.SourcePart)
        {
            return Source;
        }
        if (index == _constants.TargetPart)
        {
            return Target;
        }
        throw new NotSupportedException(); // Impossible path due to
            ↳ Ensure.ArgumentInRange
    }
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    set => throw new NotSupportedException();
}

[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
183     [MethodImpl(MethodImplOptions.AggressiveInlining)]
184     public void Clear() => throw new NotSupportedException();
185
186     [MethodImpl(MethodImplOptions.AggressiveInlining)]
187     public bool Contains(TLink item) => IndexOf(item) >= 0;
188
189     [MethodImpl(MethodImplOptions.AggressiveInlining)]
190     public void CopyTo(TLink[] array, int arrayIndex)
191     {
192         Ensure.OnDebug.ArgumentNotNull(array, nameof(array));
193         Ensure.OnDebug.ArgumentInRange(arrayIndex, new Range<int>(0, array.Length - 1),
194             ↪ nameof(arrayIndex));
195         if (arrayIndex + Length > array.Length)
196         {
197             throw new InvalidOperationException();
198         }
199         array[arrayIndex++] = Index;
200         array[arrayIndex++] = Source;
201         array[arrayIndex] = Target;
202     }
203
204     [MethodImpl(MethodImplOptions.AggressiveInlining)]
205     public bool Remove(TLink item) => Throw.A.NotSupportedExceptionAndReturn<bool>();
206
207     [MethodImpl(MethodImplOptions.AggressiveInlining)]
208     public int IndexOf(TLink item)
209     {
210         if (_equalityComparer.Equals(Index, item))
211         {
212             return _constants.IndexPart;
213         }
214         if (_equalityComparer.Equals(Source, item))
215         {
216             return _constants.SourcePart;
217         }
218         if (_equalityComparer.Equals(Target, item))
219         {
220             return _constants.TargetPart;
221         }
222         return -1;
223     }
224
225     [MethodImpl(MethodImplOptions.AggressiveInlining)]
226     public void Insert(int index, TLink item) => throw new NotSupportedException();
227
228     [MethodImpl(MethodImplOptions.AggressiveInlining)]
229     public void RemoveAt(int index) => throw new NotSupportedException();
230
231     [MethodImpl(MethodImplOptions.AggressiveInlining)]
232     public static bool operator ==(Link<TLink> left, Link<TLink> right) =>
233         ↪ left.Equals(right);
234
235     [MethodImpl(MethodImplOptions.AggressiveInlining)]
236     public static bool operator !=(Link<TLink> left, Link<TLink> right) => !(left == right);
237
238     #endregion
239 }

```

1.25 ./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 }

```

1.26 ./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 }

```

1.27 ./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 }

```

1.28 ./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 }

```

1.29 ./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 }
```

1.30 ./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 }
```

1.31 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksRecursionlessSizeBalancedTreeMethod

```
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 ExternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink> :
14         ↳ RecursionlessSizeBalancedTreeMethods<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)]
26         protected ExternalLinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink>
27             ↳ constants, byte* linksDataParts, byte* linksIndexParts, byte* header)
28         {
29             LinksDataParts = linksDataParts;
30             LinksIndexParts = linksIndexParts;
31             Header = header;
32             Break = constants.Break;
33             Continue = constants.Continue;
34         }
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected abstract TLink GetTreeRoot();
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected abstract TLink GetBasePartValue(TLink link);
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
44             ↳ rootSource, TLink rootTarget);
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
48             ↳ rootSource, TLink rootTarget);
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
52             ↳ AsRef<LinksHeader<TLink>>(Header);
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
56             ↳ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
57             ↳ _addressToInt64Converter.Convert(link)));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
61             ↳ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
62             ↳ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
66         {
67             ref var link = ref GetLinkDataPartReference(linkIndex);
68             return new Link<TLink>(linkIndex, link.Source, link.Target);
69         }
70
71         [MethodImpl(MethodImplOptions.AggressiveInlining)]
72         protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
73         {
74             ref var firstLink = ref GetLinkDataPartReference(first);
75             ref var secondLink = ref GetLinkDataPartReference(second);
76             return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
77             ↳ secondLink.Source, secondLink.Target);
78         }
79
80         [MethodImpl(MethodImplOptions.AggressiveInlining)]
81         protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
82         {
83             ref var firstLink = ref GetLinkDataPartReference(first);
84             ref var secondLink = ref GetLinkDataPartReference(second);
85             return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
86             ↳ secondLink.Source, secondLink.Target);
87         }
88
89         public TLink this[TLink index]

```

```

78 {
79     [MethodImpl(MethodImplOptions.AggressiveInlining)]
80     get
81     {
82         var root = GetTreeRoot();
83         if (GreaterOrEqualThan(index, GetSize(root)))
84         {
85             return Zero;
86         }
87         while (!EqualToZero(root))
88         {
89             var left = GetLeftOrDefault(root);
90             var leftSize = GetSizeOrZero(left);
91             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         }

```

```

152         else
153         {
154             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
155             root = GetLeftOrDefault(root);
156         }
157     }
158     root = GetTreeRoot();
159     var totalLeftIgnore = Zero;
160     while (!EqualToZero(root))
161     {
162         var @base = GetBasePartValue(root);
163         if (GreaterOrEqualThan(@base, link))
164         {
165             root = GetLeftOrDefault(root);
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(' - ');

```

```

229         sb.Append('>');
230         sb.Append(link.Target);
231     }
232 }
233 }

```

1.32 ./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)]
26         protected ExternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants,
27             ↳ byte* linksDataParts, byte* linksIndexParts, byte* header)
28         {
29             LinksDataParts = linksDataParts;
30             LinksIndexParts = linksIndexParts;
31             Header = header;
32             Break = constants.Break;
33             Continue = constants.Continue;
34         }
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected abstract TLink GetTreeRoot();
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected abstract TLink GetBasePartValue(TLink link);
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
44             ↳ rootSource, TLink rootTarget);
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
48             ↳ rootSource, TLink rootTarget);
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
52             ↳ AsRef<LinksHeader<TLink>>(Header);
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
56             ↳ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
57             ↳ _addressToInt64Converter.Convert(link)));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
61             ↳ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
62             ↳ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
66         {
67             ref var link = ref GetLinkDataPartReference(linkIndex);
68             return new Link<TLink>(linkIndex, link.Source, link.Target);
69         }
70
71         [MethodImpl(MethodImplOptions.AggressiveInlining)]
72         protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
73         {

```

```

64     ref var firstLink = ref GetLinkDataPartReference(first);
65     ref var secondLink = ref GetLinkDataPartReference(second);
66     return FirstIsToTheLeftOfSecond(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 GetLinkDataPartReference(first);
73     ref var secondLink = ref GetLinkDataPartReference(second);
74     return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
    ↪ secondLink.Source, secondLink.Target);
75 }
76
77 public TLink this[TLink index]
78 {
79     [MethodImpl(MethodImplOptions.AggressiveInlining)]
80     get
81     {
82         var root = GetTreeRoot();
83         if (GreaterOrEqualThan(index, GetSize(root)))
84         {
85             return Zero;
86         }
87         while (!EqualToZero(root))
88         {
89             var left = GetLeftOrDefault(root);
90             var leftSize = GetSizeOrZero(left);
91             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
    ↪ broken)
104     }
105 }
106
107 /// <summary>
108 /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
    ↪ (концом).
109 /// </summary>
110 /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
111 /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
112 /// <returns>Индекс искомой связи.</returns>
113 [MethodImpl(MethodImplOptions.AggressiveInlining)]
114 public TLink Search(TLink source, TLink target)
115 {
116     var root = GetTreeRoot();
117     while (!EqualToZero(root))
118     {
119         ref var rootLink = ref GetLinkDataPartReference(root);
120         var rootSource = rootLink.Source;
121         var rootTarget = rootLink.Target;
122         if (FirstIsToTheLeftOfSecond(source, target, rootSource, rootTarget)) //
    ↪ node.Key < root.Key
123         {
124             root = GetLeftOrDefault(root);
125         }
126         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
    ↪ node.Key > root.Key
127         {
128             root = GetRightOrDefault(root);
129         }
130         else // node.Key == root.Key
131         {
132             return root;
133         }
134     }
135     return Zero;

```

```

136     }
137
138     // TODO: Return indices range instead of references count
139     [MethodImpl(MethodImplOptions.AggressiveInlining)]
140     public TLink CountUsages(TLink link)
141     {
142         var root = GetTreeRoot();
143         var total = GetSize(root);
144         var totalRightIgnore = Zero;
145         while (!EqualToZero(root))
146         {
147             var @base = GetBasePartValue(root);
148             if (LessOrEqualThan(@base, link))
149             {
150                 root = GetRightOrDefault(root);
151             }
152             else
153             {
154                 totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
155                 root = GetLeftOrDefault(root);
156             }
157         }
158         root = GetTreeRoot();
159         var totalLeftIgnore = Zero;
160         while (!EqualToZero(root))
161         {
162             var @base = GetBasePartValue(root);
163             if (GreaterOrEqualThan(@base, link))
164             {
165                 root = GetLeftOrDefault(root);
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         }
217     }

```

```

213     }
214     if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
215     {
216         return @break;
217     }
218 }
219 return @continue;
220 }
221
222 [MethodImpl(MethodImplOptions.AggressiveInlining)]
223 protected override void PrintNodeValue(TLink node, StringBuilder sb)
224 {
225     ref var link = ref GetLinkDataPartReference(node);
226     sb.Append(' ');
227     sb.Append(link.Source);
228     sb.Append('-');
229     sb.Append('>');
230     sb.Append(link.Target);
231 }
232 }
233 }

```

1.33 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksSourcesRecursionlessSizeBalancedTree

```

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 ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods<TLink> :
8         ↳ ExternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
12             ↳ constants, byte* linksDataParts, byte* linksIndexParts, byte* header) :
13             ↳ base(constants, 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() => GetHeaderReference().RootAsSource;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override TLink GetBasePartValue(TLink link) =>
52             ↳ GetLinkDataPartReference(link).Source;
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

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

```

1.34 ./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> :
8          ↪ ExternalLinksSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public ExternalLinksSourcesSizeBalancedTreeMethods(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 void SetSize(TLink node, TLink size) =>
41             ↪ GetLinkIndexPartReference(node).SizeAsSource = size;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetBasePartValue(TLink link) =>
48             ↪ GetLinkDataPartReference(link).Source;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override bool FirstIsToLeftOfSecond(TLink firstSource, TLink firstTarget,
52             ↪ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
53             ↪ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));

```



```

44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
46     ↪ 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 }

```

1.35 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/ExternalLinksTargetsRecursionlessSizeBalancedTree

```

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 ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods<TLink> :
8      ↪ ExternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
12         ↪ constants, byte* linksDataParts, byte* linksIndexParts, byte* header) :
13         ↪ base(constants, 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() => GetHeaderReference().RootAsTarget;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override TLink GetBasePartValue(TLink link) =>
52         ↪ GetLinkDataPartReference(link).Target;
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
56         ↪ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
57         ↪ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

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

```

1.36 ./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> :
8          ↪ ExternalLinksSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public ExternalLinksTargetsSizeBalancedTreeMethods(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() => GetHeaderReference().RootAsTarget;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override TLink GetBasePartValue(TLink link) =>
52             ↪ GetLinkDataPartReference(link).Target;
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
56             ↪ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
57             ↪ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
61             ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
62             ↪ (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));
63     }
64 }

```

```

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

```

1.37 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksRecursionlessSizeBalancedTreeMethod

```

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 InternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink> :
14         ↪ RecursionlessSizeBalancedTreeMethods<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)]
26         protected InternalLinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink>
27             ↪ constants, byte* linksDataParts, byte* linksIndexParts, byte* header)
28         {
29             LinksDataParts = linksDataParts;
30             LinksIndexParts = linksIndexParts;
31             Header = header;
32             Break = constants.Break;
33             Continue = constants.Continue;
34         }
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected abstract TLink GetTreeRoot(TLink link);
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected abstract TLink GetBasePartValue(TLink link);
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected abstract TLink GetKeyPartValue(TLink link);
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
47             ↪ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
48             ↪ _addressToInt64Converter.Convert(link)));
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
52             ↪ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
53             ↪ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second) =>
57             ↪ LessThan(GetKeyPartValue(first), GetKeyPartValue(second));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
61             ↪ GreaterThan(GetKeyPartValue(first), GetKeyPartValue(second));
62
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
65         {
66             ref var link = ref GetLinkDataPartReference(linkIndex);
67             return new Link<TLink>(linkIndex, link.Source, link.Target);
68         }
69     }
70 }

```

```

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
88                             ↳ broken)
89         }
90     }
91
92     /// <summary>
93     /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
94     /// ↳ (концом).
95     /// </summary>
96     /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
97     /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
98     /// <returns>Индекс искомой связи.</returns>
99     [MethodImpl(MethodImplOptions.AggressiveInlining)]
100     public abstract TLink Search(TLink source, TLink target);
101
102     [MethodImpl(MethodImplOptions.AggressiveInlining)]
103     protected TLink SearchCore(TLink root, TLink key)
104     {
105         while (!EqualToZero(root))
106         {
107             var rootKey = GetKeyPartValue(root);
108             if (LessThan(key, rootKey)) // node.Key < root.Key
109             {
110                 root = GetLeftOrDefault(root);
111             }
112             else if (GreaterThan(key, rootKey)) // node.Key > root.Key
113             {
114                 root = GetRightOrDefault(root);
115             }
116             else // node.Key == root.Key
117             {
118                 return root;
119             }
120         }
121         return Zero;
122     }
123
124     // TODO: Return indices range instead of references count
125     [MethodImpl(MethodImplOptions.AggressiveInlining)]
126     public TLink CountUsages(TLink link) => GetSizeOrZero(GetTreeRoot(link));
127
128     [MethodImpl(MethodImplOptions.AggressiveInlining)]
129     public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
130         ↳ EachUsageCore(@base, GetTreeRoot(@base), handler);
131
132     // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
133     ↳ low-level MSIL stack.
134     [MethodImpl(MethodImplOptions.AggressiveInlining)]
135     private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
136     {

```

```

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 }

```

1.38 ./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> :
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)]
26         protected InternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants,
27             ↳ byte* linksDataParts, byte* linksIndexParts, byte* header)
28         {
29             LinksDataParts = linksDataParts;
30             LinksIndexParts = linksIndexParts;
31             Header = header;
32             Break = constants.Break;
33             Continue = constants.Continue;
34         }
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected abstract TLink GetTreeRoot(TLink link);
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected abstract TLink GetBasePartValue(TLink link);
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

43     protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
44     ↪ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
45     ↪ _addressToInt64Converter.Convert(link)));
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
49     ↪ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
50     ↪ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second) =>
54     ↪ LessThan(GetKeyPartValue(first), GetKeyPartValue(second));
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
58     ↪ GreaterThan(GetKeyPartValue(first), GetKeyPartValue(second));
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
62     {
63         ref var link = ref GetLinkDataPartReference(linkIndex);
64         return new Link<TLink>(linkIndex, link.Source, link.Target);
65     }
66
67     public TLink this[TLink link, TLink index]
68     {
69         [MethodImpl(MethodImplOptions.AggressiveInlining)]
70         get
71         {
72             var root = GetTreeRoot(link);
73             if (GreaterOrEqualThan(index, GetSize(root)))
74             {
75                 return Zero;
76             }
77             while (!EqualToZero(root))
78             {
79                 var left = GetLeftOrDefault(root);
80                 var leftSize = GetSizeOrZero(left);
81                 if (LessThan(index, leftSize))
82                 {
83                     root = left;
84                     continue;
85                 }
86                 if (AreEqual(index, leftSize))
87                 {
88                     return root;
89                 }
90                 root = GetRightOrDefault(root);
91                 index = Subtract(index, Increment(leftSize));
92             }
93             return Zero; // TODO: Impossible situation exception (only if tree structure
94             ↪ broken)
95         }
96     }
97
98     /// <summary>
99     /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
100     ↪ (концом).
101     /// </summary>
102     /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
103     /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
104     /// <returns>Индекс искомой связи.</returns>
105     [MethodImpl(MethodImplOptions.AggressiveInlining)]
106     public abstract TLink Search(TLink source, TLink target);
107
108     [MethodImpl(MethodImplOptions.AggressiveInlining)]
109     protected TLink SearchCore(TLink root, TLink key)
110     {
111         while (!EqualToZero(root))
112         {
113             var rootKey = GetKeyPartValue(root);
114             if (LessThan(key, rootKey)) // node.Key < root.Key
115             {
116                 root = GetLeftOrDefault(root);
117             }
118             else if (GreaterThan(key, rootKey)) // node.Key > root.Key
119             {
120                 root = GetRightOrDefault(root);
121             }
122         }
123     }

```

```

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 }

```

1.39 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksSourcesLinkedListMethods.cs

```

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

```

```

21 public InternalLinksSourcesLinkedListMethods(LinksConstants<TLink> constants, byte*
    ↳ linksDataParts, byte* linksIndexParts)
22 {
23     _linksDataParts = linksDataParts;
24     _linksIndexParts = linksIndexParts;
25     Break = constants.Break;
26     Continue = constants.Continue;
27 }
28
29 [MethodImpl(MethodImplOptions.AggressiveInlining)]
30 protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
    ↳ AsRef<RawLinkDataPart<TLink>>(_linksDataParts + (RawLinkDataPart<TLink>.SizeInBytes
    ↳ * _addressToInt64Converter.Convert(link)));
31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
    ↳ ref AsRef<RawLinkIndexPart<TLink>>(_linksIndexParts +
    ↳ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 protected override TLink GetFirst(TLink head) =>
    ↳ GetLinkIndexPartReference(head).RootAsSource;
37
38 [MethodImpl(MethodImplOptions.AggressiveInlining)]
39 protected override TLink GetLast(TLink head)
40 {
41     var first = GetLinkIndexPartReference(head).RootAsSource;
42     if (EqualToZero(first))
43     {
44         return first;
45     }
46     else
47     {
48         return GetPrevious(first);
49     }
50 }
51
52 [MethodImpl(MethodImplOptions.AggressiveInlining)]
53 protected override TLink GetPrevious(TLink element) =>
    ↳ GetLinkIndexPartReference(element).LeftAsSource;
54
55 [MethodImpl(MethodImplOptions.AggressiveInlining)]
56 protected override TLink GetNext(TLink element) =>
    ↳ GetLinkIndexPartReference(element).RightAsSource;
57
58 [MethodImpl(MethodImplOptions.AggressiveInlining)]
59 protected override TLink GetSize(TLink head) =>
    ↳ GetLinkIndexPartReference(head).SizeAsSource;
60
61 [MethodImpl(MethodImplOptions.AggressiveInlining)]
62 protected override void SetFirst(TLink head, TLink element) =>
    ↳ GetLinkIndexPartReference(head).RootAsSource = element;
63
64 [MethodImpl(MethodImplOptions.AggressiveInlining)]
65 protected override void SetLast(TLink head, TLink element)
66 {
67     //var first = GetLinkIndexPartReference(head).RootAsSource;
68     //if (EqualToZero(first))
69     //{
70         // SetFirst(head, element);
71     //}
72     //else
73     //{
74         // SetPrevious(first, element);
75     //}
76 }
77
78 [MethodImpl(MethodImplOptions.AggressiveInlining)]
79 protected override void SetPrevious(TLink element, TLink previous) =>
    ↳ GetLinkIndexPartReference(element).LeftAsSource = previous;
80
81 [MethodImpl(MethodImplOptions.AggressiveInlining)]
82 protected override void SetNext(TLink element, TLink next) =>
    ↳ GetLinkIndexPartReference(element).RightAsSource = next;
83
84 [MethodImpl(MethodImplOptions.AggressiveInlining)]
85 protected override void SetSize(TLink head, TLink size) =>
    ↳ GetLinkIndexPartReference(head).SizeAsSource = size;

```



```

86 [MethodImpl(MethodImplOptions.AggressiveInlining)]
87 public TLink CountUsages(TLink head) => GetSize(head);
88
89 [MethodImpl(MethodImplOptions.AggressiveInlining)]
90 protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
91 {
92     ref var link = ref GetLinkDataPartReference(linkIndex);
93     return new Link<TLink>(linkIndex, link.Source, link.Target);
94 }
95
96 [MethodImpl(MethodImplOptions.AggressiveInlining)]
97 public TLink EachUsage(TLink source, Func<IList<TLink>, TLink> handler)
98 {
99     var @continue = Continue;
100     var @break = Break;
101     var current = GetFirst(source);
102     var first = current;
103     while (!EqualToZero(current))
104     {
105         if (AreEqual(handler(GetLinkValues(current)), @break))
106         {
107             return @break;
108         }
109         current = GetNext(current);
110         if (AreEqual(current, first))
111         {
112             return @continue;
113         }
114     }
115     return @continue;
116 }
117 }
118 }
119 }

```

1.40 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksSourcesRecursionlessSizeBalancedTree

```

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 InternalLinksSourcesRecursionlessSizeBalancedTreeMethods<TLink> :
8     ↪ InternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
12         ↪ constants, byte* linksDataParts, byte* linksIndexParts, byte* header) :
13         ↪ base(constants, 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)]

```

```

34     protected override void SetSize(TLink node, TLink size) =>
35         ↳ GetLinkIndexPartReference(node).SizeAsSource = size;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override TLink GetTreeRoot(TLink link) =>
39         ↳ GetLinkIndexPartReference(link).RootAsSource;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override TLink GetBasePartValue(TLink link) =>
43         ↳ GetLinkDataPartReference(link).Source;
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override TLink GetKeyPartValue(TLink link) =>
47         ↳ GetLinkDataPartReference(link).Target;
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override void ClearNode(TLink node)
51     {
52         ref var link = ref GetLinkIndexPartReference(node);
53         link.LeftAsSource = Zero;
54         link.RightAsSource = Zero;
55         link.SizeAsSource = Zero;
56     }
57
58     public override TLink Search(TLink source, TLink target) =>
59         ↳ SearchCore(GetTreeRoot(source), target);
60 }

```

1.41 ./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)]

```

```

37     protected override TLink GetTreeRoot(TLink link) =>
38         ↪ GetLinkIndexPartReference(link).RootAsSource;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetBasePartValue(TLink link) =>
42         ↪ GetLinkDataPartReference(link).Source;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override TLink GetKeyPartValue(TLink link) =>
46         ↪ GetLinkDataPartReference(link).Target;
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 }

```

1.42 ./csharp/Platform.Data.Doublets/Memory/Split/Generic/InternalLinksTargetsRecursionlessSizeBalancedTree

```

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 InternalLinksTargetsRecursionlessSizeBalancedTreeMethods<TLink> :
8          ↪ InternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
12             ↪ constants, byte* linksDataParts, byte* linksIndexParts, byte* header) :
13             ↪ base(constants, 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)]

```

```

40     protected override TLink GetBasePartValue(TLink link) =>
41         ↪ GetLinkDataPartReference(link).Target;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override TLink GetKeyPartValue(TLink link) =>
45         ↪ GetLinkDataPartReference(link).Source;
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override void ClearNode(TLink node)
49     {
50         ref var link = ref GetLinkIndexPartReference(node);
51         link.LeftAsTarget = Zero;
52         link.RightAsTarget = Zero;
53         link.SizeAsTarget = Zero;
54     }
55
56     public override TLink Search(TLink source, TLink target) =>
57         ↪ SearchCore(GetTreeRoot(target), source);
58 }

```

1.43 ./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)]

```

```

43     protected override TLink GetKeyPartValue(TLink link) =>
44         ↪ GetLinkDataPartReference(link).Source;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override void ClearNode(TLink node)
48     {
49         ref var link = ref GetLinkIndexPartReference(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 }

```

1.44 ./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             ↪ IndexTreeType.Default, useLinkedList: true) { }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
33             ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants) :
34             ↪ this(dataMemory, indexMemory, memoryReservationStep, constants,
35             ↪ IndexTreeType.Default, useLinkedList: true) { }
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
39             ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants,
40             ↪ IndexTreeType indexTreeType, bool useLinkedList) : base(dataMemory, indexMemory,
41             ↪ memoryReservationStep, constants, useLinkedList)
42         {
43             if (indexTreeType == IndexTreeType.SizeBalancedTree)
44             {
45                 _createInternalSourceTreeMethods = () => new
46                     ↪ InternalLinksSourcesSizeBalancedTreeMethods<TLink>(Constants,
47                     ↪ _linksDataParts, _linksIndexParts, _header);
48                 _createExternalSourceTreeMethods = () => new
49                     ↪ ExternalLinksSourcesSizeBalancedTreeMethods<TLink>(Constants,
50                     ↪ _linksDataParts, _linksIndexParts, _header);
51                 _createInternalTargetTreeMethods = () => new
52                     ↪ InternalLinksTargetsSizeBalancedTreeMethods<TLink>(Constants,
53                     ↪ _linksDataParts, _linksIndexParts, _header);
54                 _createExternalTargetTreeMethods = () => new
55                     ↪ ExternalLinksTargetsSizeBalancedTreeMethods<TLink>(Constants,
56                     ↪ _linksDataParts, _linksIndexParts, _header);
57             }
58             else
59             {

```

```

42         _createInternalSourceTreeMethods = () => new
            ↳ InternalLinksSourcesRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
43         _createExternalSourceTreeMethods = () => new
            ↳ ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
44         _createInternalTargetTreeMethods = () => new
            ↳ InternalLinksTargetsRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
45         _createExternalTargetTreeMethods = () => new
            ↳ ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
46     }
47     Init(dataMemory, indexMemory);
48 }
49
50 [MethodImpl(MethodImplOptions.AggressiveInlining)]
51 protected override void SetPointers(IResizableDirectMemory dataMemory,
    ↳ IResizableDirectMemory indexMemory)
52 {
53     _linksDataParts = (byte*)dataMemory.Pointer;
54     _linksIndexParts = (byte*)indexMemory.Pointer;
55     _header = _linksIndexParts;
56     if (_useLinkedList)
57     {
58         InternalSourcesListMethods = new
            ↳ InternalLinksSourcesLinkedListMethods<TLink>(Constants, _linksDataParts,
            ↳ _linksIndexParts);
59     }
60     else
61     {
62         InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
63     }
64     ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
65     InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
66     ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
67     UnusedLinksListMethods = new UnusedLinksListMethods<TLink>(_linksDataParts, _header);
68 }
69
70 [MethodImpl(MethodImplOptions.AggressiveInlining)]
71 protected override void ResetPointers()
72 {
73     base.ResetPointers();
74     _linksDataParts = null;
75     _linksIndexParts = null;
76     _header = null;
77 }
78
79 [MethodImpl(MethodImplOptions.AggressiveInlining)]
80 protected override ref LinksHeader<TLink> GetHeaderReference() => ref
    ↳ AsRef<LinksHeader<TLink>>(_header);
81
82 [MethodImpl(MethodImplOptions.AggressiveInlining)]
83 protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
    ↳ => ref AsRef<RawLinkDataPart<TLink>>(_linksDataParts + (LinkDataPartSizeInBytes *
    ↳ ConvertToInt64(linkIndex)));
84
85 [MethodImpl(MethodImplOptions.AggressiveInlining)]
86 protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
    ↳ linkIndex) => ref AsRef<RawLinkIndexPart<TLink>>(_linksIndexParts +
    ↳ (LinkIndexPartSizeInBytes * ConvertToInt64(linkIndex)));
87 }
88 }

```

1.45 ./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 bool _useLinkedList;
45     protected readonly long _dataMemoryReservationStepInBytes;
46     protected readonly long _indexMemoryReservationStepInBytes;
47
48     protected InternalLinksSourcesLinkedListMethods<TLink> InternalSourcesListMethods;
49     protected ILinksTreeMethods<TLink> InternalSourcesTreeMethods;
50     protected ILinksTreeMethods<TLink> ExternalSourcesTreeMethods;
51     protected ILinksTreeMethods<TLink> InternalTargetsTreeMethods;
52     protected ILinksTreeMethods<TLink> ExternalTargetsTreeMethods;
53     // TODO: Возможно чтобы гарантированно проверять на то, является ли связь удалённой,
54     // ↳ нужно использовать не список а дерево, так как так можно быстрее проверить на
55     // ↳ наличие связи внутри
56     protected ILinksListMethods<TLink> UnusedLinksListMethods;
57
58     /// <summary>
59     ///     Возвращает общее число связей находящихся в хранилище.
60     /// </summary>
61     protected virtual TLink Total
62     {
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         get
65         {
66             ref var header = ref GetHeaderReference();
67             return Subtract(header.AllocatedLinks, header.FreeLinks);
68         }
69     }
70
71     public virtual LinksConstants<TLink> Constants
72     {
73         [MethodImpl(MethodImplOptions.AggressiveInlining)]
74         get;
75     }
76
77     [MethodImpl(MethodImplOptions.AggressiveInlining)]
78     protected SplitMemoryLinksBase(IResizableDirectMemory dataMemory, IResizableDirectMemory
79         ↳ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants, bool
80         ↳ useLinkedList)
81     {
82         _dataMemory = dataMemory;
83         _indexMemory = indexMemory;
84         _dataMemoryReservationStepInBytes = memoryReservationStep * LinkDataPartSizeInBytes;
85         _indexMemoryReservationStepInBytes = memoryReservationStep *
86             ↳ LinkIndexPartSizeInBytes;
87         _useLinkedList = useLinkedList;
88         Constants = constants;
89     }
90
91     [MethodImpl(MethodImplOptions.AggressiveInlining)]
92     protected SplitMemoryLinksBase(IResizableDirectMemory dataMemory, IResizableDirectMemory
93         ↳ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
94         ↳ memoryReservationStep, Default<LinksConstants<TLink>>.Instance, useLinkedList: true)
95     {
96     }

```

```

84 [MethodImpl(MethodImplOptions.AggressiveInlining)]
85 protected virtual void Init(IResizableDirectMemory dataMemory, IResizableDirectMemory
86     ↪ indexMemory)
87 {
88     // Read allocated links from header
89     if (indexMemory.ReservedCapacity < LinkHeaderSizeInBytes)
90     {
91         indexMemory.ReservedCapacity = LinkHeaderSizeInBytes;
92     }
93     SetPointers(dataMemory, indexMemory);
94     ref var header = ref GetHeaderReference();
95     var allocatedLinks = ConvertToInt64(header.AllocatedLinks);
96     // Adjust reserved capacity
97     var minimumDataReservedCapacity = allocatedLinks * LinkDataPartSizeInBytes;
98     if (minimumDataReservedCapacity < dataMemory.UsedCapacity)
99     {
100         minimumDataReservedCapacity = dataMemory.UsedCapacity;
101     }
102     if (minimumDataReservedCapacity < _dataMemoryReservationStepInBytes)
103     {
104         minimumDataReservedCapacity = _dataMemoryReservationStepInBytes;
105     }
106     var minimumIndexReservedCapacity = allocatedLinks * LinkDataPartSizeInBytes;
107     if (minimumIndexReservedCapacity < indexMemory.UsedCapacity)
108     {
109         minimumIndexReservedCapacity = indexMemory.UsedCapacity;
110     }
111     if (minimumIndexReservedCapacity < _indexMemoryReservationStepInBytes)
112     {
113         minimumIndexReservedCapacity = _indexMemoryReservationStepInBytes;
114     }
115     // Check for alignment
116     if (minimumDataReservedCapacity % _dataMemoryReservationStepInBytes > 0)
117     {
118         minimumDataReservedCapacity = ((minimumDataReservedCapacity /
119             ↪ _dataMemoryReservationStepInBytes) * _dataMemoryReservationStepInBytes) +
120             ↪ _dataMemoryReservationStepInBytes;
121     }
122     if (minimumIndexReservedCapacity % _indexMemoryReservationStepInBytes > 0)
123     {
124         minimumIndexReservedCapacity = ((minimumIndexReservedCapacity /
125             ↪ _indexMemoryReservationStepInBytes) * _indexMemoryReservationStepInBytes) +
126             ↪ _indexMemoryReservationStepInBytes;
127     }
128     if (dataMemory.ReservedCapacity != minimumDataReservedCapacity)
129     {
130         dataMemory.ReservedCapacity = minimumDataReservedCapacity;
131     }
132     if (indexMemory.ReservedCapacity != minimumIndexReservedCapacity)
133     {
134         indexMemory.ReservedCapacity = minimumIndexReservedCapacity;
135     }
136     SetPointers(dataMemory, indexMemory);
137     header = ref GetHeaderReference();
138     // Ensure correctness _memory.UsedCapacity over _header->AllocatedLinks
139     // Гарантия корректности _memory.UsedCapacity относительно _header->AllocatedLinks
140     dataMemory.UsedCapacity = (ConvertToInt64(header.AllocatedLinks) *
141         ↪ LinkDataPartSizeInBytes) + LinkDataPartSizeInBytes; // First link is read only
142         ↪ zero link.
143     indexMemory.UsedCapacity = (ConvertToInt64(header.AllocatedLinks) *
144         ↪ LinkIndexPartSizeInBytes) + LinkHeaderSizeInBytes;
145     // Ensure correctness _memory.ReservedLinks over _header->ReservedCapacity
146     // Гарантия корректности _header->ReservedLinks относительно _memory.ReservedCapacity
147     header.ReservedLinks = ConvertToAddress((dataMemory.ReservedCapacity -
148         ↪ LinkDataPartSizeInBytes) / LinkDataPartSizeInBytes);
149 }
150
151 [MethodImpl(MethodImplOptions.AggressiveInlining)]
152 public virtual TLink Count(ICollection<TLink> restrictions)
153 {
154     // Если нет ограничений, тогда возвращаем общее число связей находящихся в хранилище.
155     if (restrictions.Count == 0)
156     {
157         return Total;
158     }
159     var constants = Constants;
160     var any = constants.Any;

```



```

153 var index = restrictions[constants.IndexPart];
154 if (restrictions.Count == 1)
155 {
156     if (AreEqual(index, any))
157     {
158         return Total;
159     }
160     return Exists(index) ? GetOne() : GetZero();
161 }
162 if (restrictions.Count == 2)
163 {
164     var value = restrictions[1];
165     if (AreEqual(index, any))
166     {
167         if (AreEqual(value, any))
168         {
169             return Total; // Any - как отсутствие ограничения
170         }
171         var externalReferencesRange = constants.ExternalReferencesRange;
172         if (externalReferencesRange.HasValue &&
173             ⇨ externalReferencesRange.Value.Contains(value))
174         {
175             return Add(ExternalSourcesTreeMethods.CountUsages(value),
176                 ⇨ ExternalTargetsTreeMethods.CountUsages(value));
177         }
178         else
179         {
180             if (_useLinkedList)
181             {
182                 return Add(InternalSourcesListMethods.CountUsages(value),
183                     ⇨ InternalTargetsTreeMethods.CountUsages(value));
184             }
185             else
186             {
187                 return Add(InternalSourcesTreeMethods.CountUsages(value),
188                     ⇨ InternalTargetsTreeMethods.CountUsages(value));
189             }
190         }
191     }
192     else
193     {
194         if (!Exists(index))
195         {
196             return GetZero();
197         }
198         if (AreEqual(value, any))
199         {
200             return GetOne();
201         }
202         ref var storedLinkValue = ref GetLinkDataPartReference(index);
203         if (AreEqual(storedLinkValue.Source, value) ||
204             ⇨ AreEqual(storedLinkValue.Target, value))
205         {
206             return GetOne();
207         }
208         return GetZero();
209     }
210 }
211 if (restrictions.Count == 3)
212 {
213     var externalReferencesRange = constants.ExternalReferencesRange;
214     var source = restrictions[constants.SourcePart];
215     var target = restrictions[constants.TargetPart];
216     if (AreEqual(index, any))
217     {
218         if (AreEqual(source, any) && AreEqual(target, any))
219         {
220             return Total;
221         }
222         else if (AreEqual(source, any))
223         {
224             if (externalReferencesRange.HasValue &&
225                 ⇨ externalReferencesRange.Value.Contains(target))
226             {
227                 return ExternalTargetsTreeMethods.CountUsages(target);
228             }
229             else
230             {
231                 return GetZero();
232             }
233         }
234         else if (AreEqual(target, any))
235         {
236             if (externalReferencesRange.HasValue &&
237                 ⇨ externalReferencesRange.Value.Contains(source))
238             {
239                 return ExternalTargetsTreeMethods.CountUsages(source);
240             }
241             else
242             {
243                 return GetZero();
244             }
245         }
246         else
247         {
248             return GetZero();
249         }
250     }
251     else
252     {
253         if (AreEqual(source, any) && AreEqual(target, any))
254         {
255             return Total;
256         }
257         else if (AreEqual(source, any))
258         {
259             if (externalReferencesRange.HasValue &&
260                 ⇨ externalReferencesRange.Value.Contains(target))
261             {
262                 return ExternalTargetsTreeMethods.CountUsages(target);
263             }
264             else
265             {
266                 return GetZero();
267             }
268         }
269         else if (AreEqual(target, any))
270         {
271             if (externalReferencesRange.HasValue &&
272                 ⇨ externalReferencesRange.Value.Contains(source))
273             {
274                 return ExternalTargetsTreeMethods.CountUsages(source);
275             }
276             else
277             {
278                 return GetZero();
279             }
280         }
281         else
282         {
283             return GetZero();
284         }
285     }
286 }

```

```

225         return InternalTargetsTreeMethods.CountUsages(target);
226     }
227 }
228 else if (AreEqual(target, any))
229 {
230     if (externalReferencesRange.HasValue &&
231         ↳ externalReferencesRange.Value.Contains(source))
232     {
233         return ExternalSourcesTreeMethods.CountUsages(source);
234     }
235     else
236     {
237         if (_useLinkedList)
238         {
239             return InternalSourcesListMethods.CountUsages(source);
240         }
241         else
242         {
243             return InternalSourcesTreeMethods.CountUsages(source);
244         }
245     }
246 }
247 else //if(source != Any && target != Any)
248 {
249     // Эквивалент Exists(source, target) => Count(Any, source, target) > 0
250     TLink link;
251     if (externalReferencesRange.HasValue)
252     {
253         if (externalReferencesRange.Value.Contains(source) &&
254             ↳ externalReferencesRange.Value.Contains(target))
255         {
256             link = ExternalSourcesTreeMethods.Search(source, target);
257         }
258         else if (externalReferencesRange.Value.Contains(source))
259         {
260             link = InternalTargetsTreeMethods.Search(source, target);
261         }
262         else if (externalReferencesRange.Value.Contains(target))
263         {
264             if (_useLinkedList)
265             {
266                 link = ExternalSourcesTreeMethods.Search(source, target);
267             }
268             else
269             {
270                 link = InternalSourcesTreeMethods.Search(source, target);
271             }
272         }
273         else
274         {
275             if (_useLinkedList ||
276                 ↳ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
277                 ↳ InternalTargetsTreeMethods.CountUsages(target)))
278             {
279                 link = InternalTargetsTreeMethods.Search(source, target);
280             }
281             else
282             {
283                 link = InternalSourcesTreeMethods.Search(source, target);
284             }
285         }
286     }
287 }
288 else
289 {
290     if (_useLinkedList ||
291         ↳ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
292         ↳ InternalTargetsTreeMethods.CountUsages(target)))
293     {
294         link = InternalTargetsTreeMethods.Search(source, target);
295     }
296     else
297     {
298         link = InternalSourcesTreeMethods.Search(source, target);
299     }
300 }
301 return AreEqual(link, constants.Null) ? GetZero() : GetOne();
302 }
303 }

```

```

297     else
298     {
299         if (!Exists(index))
300         {
301             return GetZero();
302         }
303         if (AreEqual(source, any) && AreEqual(target, any))
304         {
305             return GetOne();
306         }
307         ref var storedLinkValue = ref GetLinkDataPartReference(index);
308         if (!AreEqual(source, any) && !AreEqual(target, any))
309         {
310             if (AreEqual(storedLinkValue.Source, source) &&
311                 ⇨ AreEqual(storedLinkValue.Target, target))
312             {
313                 return GetOne();
314             }
315             return GetZero();
316         }
317         var value = default(TLink);
318         if (AreEqual(source, any))
319         {
320             value = target;
321         }
322         if (AreEqual(target, any))
323         {
324             value = source;
325         }
326         if (AreEqual(storedLinkValue.Source, value) ||
327             ⇨ AreEqual(storedLinkValue.Target, value))
328         {
329             return GetOne();
330         }
331         return GetZero();
332     }
333 }
334
335 [MethodImpl(MethodImplOptions.AggressiveInlining)]
336 public virtual TLink Each(Func<IList<TLink>, TLink> handler, IList<TLink> restrictions)
337 {
338     var constants = Constants;
339     var @break = constants.Break;
340     if (restrictions.Count == 0)
341     {
342         for (var link = GetOne(); LessOrEqualThan(link,
343             ⇨ GetHeaderReference().AllocatedLinks); link = Increment(link))
344         {
345             if (Exists(link) && AreEqual(handler(GetLinkStruct(link)), @break))
346             {
347                 return @break;
348             }
349         }
350         return @break;
351     }
352     var @continue = constants.Continue;
353     var any = constants.Any;
354     var index = restrictions[constants.IndexPart];
355     if (restrictions.Count == 1)
356     {
357         if (AreEqual(index, any))
358         {
359             return Each(handler, Array.Empty<TLink>());
360         }
361         if (!Exists(index))
362         {
363             return @continue;
364         }
365         return handler(GetLinkStruct(index));
366     }
367     if (restrictions.Count == 2)
368     {
369         var value = restrictions[1];
370         if (AreEqual(index, any))
371         {

```

```

371         if (AreEqual(value, any))
372         {
373             return Each(handler, Array.Empty<TLink>());
374         }
375         if (AreEqual(Each(handler, new Link<TLink>(index, value, any)), @break))
376         {
377             return @break;
378         }
379         return Each(handler, new Link<TLink>(index, any, value));
380     }
381     else
382     {
383         if (!Exists(index))
384         {
385             return @continue;
386         }
387         if (AreEqual(value, any))
388         {
389             return handler(GetLinkStruct(index));
390         }
391         ref var storedLinkValue = ref GetLinkDataPartReference(index);
392         if (AreEqual(storedLinkValue.Source, value) ||
393             AreEqual(storedLinkValue.Target, value))
394         {
395             return handler(GetLinkStruct(index));
396         }
397         return @continue;
398     }
399 }
400 if (restrictions.Count == 3)
401 {
402     var externalReferencesRange = constants.ExternalReferencesRange;
403     var source = restrictions[constants.SourcePart];
404     var target = restrictions[constants.TargetPart];
405     if (AreEqual(index, any))
406     {
407         if (AreEqual(source, any) && AreEqual(target, any))
408         {
409             return Each(handler, Array.Empty<TLink>());
410         }
411         else if (AreEqual(source, any))
412         {
413             if (externalReferencesRange.HasValue &&
414                 ⇨ externalReferencesRange.Value.Contains(target))
415             {
416                 return ExternalTargetsTreeMethods.EachUsage(target, handler);
417             }
418             else
419             {
420                 return InternalTargetsTreeMethods.EachUsage(target, handler);
421             }
422         }
423         else if (AreEqual(target, any))
424         {
425             if (externalReferencesRange.HasValue &&
426                 ⇨ externalReferencesRange.Value.Contains(source))
427             {
428                 return ExternalSourcesTreeMethods.EachUsage(source, handler);
429             }
430             else
431             {
432                 if (_useLinkedList)
433                 {
434                     return InternalSourcesListMethods.EachUsage(source, handler);
435                 }
436                 else
437                 {
438                     return InternalSourcesTreeMethods.EachUsage(source, handler);
439                 }
440             }
441         }
442         else //if(source != Any && target != Any)
443         {
444             TLink link;
445             if (externalReferencesRange.HasValue)
446             {
447                 if (externalReferencesRange.Value.Contains(source) &&
448                     ⇨ externalReferencesRange.Value.Contains(target))

```

```

446     {
447         link = ExternalSourcesTreeMethods.Search(source, target);
448     }
449     else if (externalReferencesRange.Value.Contains(source))
450     {
451         link = InternalTargetsTreeMethods.Search(source, target);
452     }
453     else if (externalReferencesRange.Value.Contains(target))
454     {
455         if (_useLinkedList)
456         {
457             link = ExternalSourcesTreeMethods.Search(source, target);
458         }
459         else
460         {
461             link = InternalSourcesTreeMethods.Search(source, target);
462         }
463     }
464     else
465     {
466         if (_useLinkedList ||
467             ↪ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
468             ↪ InternalTargetsTreeMethods.CountUsages(target)))
469         {
470             link = InternalTargetsTreeMethods.Search(source, target);
471         }
472         else
473         {
474             link = InternalSourcesTreeMethods.Search(source, target);
475         }
476     }
477 }
478 else
479 {
480     if (_useLinkedList ||
481         ↪ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
482         ↪ InternalTargetsTreeMethods.CountUsages(target)))
483     {
484         link = InternalTargetsTreeMethods.Search(source, target);
485     }
486     else
487     {
488         link = InternalSourcesTreeMethods.Search(source, target);
489     }
490 }
491 return AreEqual(link, constants.Null) ? @continue :
492     ↪ handler(GetLinkStruct(link));
493 }
494 else
495 {
496     if (!Exists(index))
497     {
498         return @continue;
499     }
500     if (AreEqual(source, any) && AreEqual(target, any))
501     {
502         return handler(GetLinkStruct(index));
503     }
504     ref var storedLinkValue = ref GetLinkDataPartReference(index);
505     if (!AreEqual(source, any) && !AreEqual(target, any))
506     {
507         if (AreEqual(storedLinkValue.Source, source) &&
508             AreEqual(storedLinkValue.Target, target))
509         {
510             return handler(GetLinkStruct(index));
511         }
512     }
513     return @continue;
514 }
515 var value = default(TLink);
516 if (AreEqual(source, any))
517 {
518     value = target;
519 }
520 if (AreEqual(target, any))
521 {
522     value = source;
523 }

```

```

519         if (AreEqual(storedLinkValue.Source, value) ||
520             AreEqual(storedLinkValue.Target, value))
521         {
522             return handler(GetLinkStruct(index));
523         }
524         return @continue;
525     }
526 }
527 throw new NotSupportedException("Другие размеры и способы ограничений не
    ↳ поддерживаются.");
528 }
529
530 /// <remarks>
531 /// TODO: Возможно можно перемещать значения, если указан индекс, но значение существует
    ↳ в другом месте (но не в менеджере памяти, а в логике Links)
532 /// </remarks>
533 [MethodImpl(MethodImplOptions.AggressiveInlining)]
534 public virtual TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
535 {
536     var constants = Constants;
537     var @null = constants.Null;
538     var externalReferencesRange = constants.ExternalReferencesRange;
539     var linkIndex = restrictions[constants.IndexPart];
540     ref var link = ref GetLinkDataPartReference(linkIndex);
541     var source = link.Source;
542     var target = link.Target;
543     ref var header = ref GetHeaderReference();
544     ref var rootAsSource = ref header.RootAsSource;
545     ref var rootAsTarget = ref header.RootAsTarget;
546     // Будет корректно работать только в том случае, если пространство выделенной связи
    ↳ предварительно заполнено нулями
547     if (!AreEqual(source, @null))
548     {
549         if (externalReferencesRange.HasValue &&
550             ↳ externalReferencesRange.Value.Contains(source))
551         {
552             ExternalSourcesTreeMethods.Detach(ref rootAsSource, linkIndex);
553         }
554         else
555         {
556             if (_useLinkedList)
557             {
558                 InternalSourcesListMethods.Detach(source, linkIndex);
559             }
560             else
561             {
562                 InternalSourcesTreeMethods.Detach(ref
563                     ↳ GetLinkIndexPartReference(source).RootAsSource, linkIndex);
564             }
565         }
566     }
567     if (!AreEqual(target, @null))
568     {
569         if (externalReferencesRange.HasValue &&
570             ↳ externalReferencesRange.Value.Contains(target))
571         {
572             ExternalTargetsTreeMethods.Detach(ref rootAsTarget, linkIndex);
573         }
574         else
575         {
576             InternalTargetsTreeMethods.Detach(ref
577                 ↳ GetLinkIndexPartReference(target).RootAsTarget, linkIndex);
578         }
579     }
580     source = link.Source = substitution[constants.SourcePart];
581     target = link.Target = substitution[constants.TargetPart];
582     if (!AreEqual(source, @null))
583     {
584         if (externalReferencesRange.HasValue &&
585             ↳ externalReferencesRange.Value.Contains(source))
586         {
587             ExternalSourcesTreeMethods.Attach(ref rootAsSource, linkIndex);
588         }
589         else
590         {
591             if (_useLinkedList)
592             {
593                 InternalSourcesListMethods.AttachAsLast(source, linkIndex);
594             }
595             else
596             {
597                 InternalSourcesTreeMethods.Attach(ref rootAsSource, linkIndex);
598             }
599         }
600     }
601     if (!AreEqual(target, @null))
602     {
603         if (externalReferencesRange.HasValue &&
604             ↳ externalReferencesRange.Value.Contains(target))
605         {
606             ExternalTargetsTreeMethods.Attach(ref rootAsTarget, linkIndex);
607         }
608         else
609         {
610             if (_useLinkedList)
611             {
612                 InternalTargetsListMethods.AttachAsLast(target, linkIndex);
613             }
614             else
615             {
616                 InternalTargetsTreeMethods.Attach(ref rootAsTarget, linkIndex);
617             }
618         }
619     }
620 }

```

```

589     }
590     else
591     {
592         InternalSourcesTreeMethods.Attach(ref
593             ↪ GetLinkIndexPartReference(source).RootAsSource, linkIndex);
594     }
595 }
596 if (!AreEqual(target, @null))
597 {
598     if (externalReferencesRange.HasValue &&
599         ↪ externalReferencesRange.Value.Contains(target))
600     {
601         ExternalTargetsTreeMethods.Attach(ref rootAsTarget, linkIndex);
602     }
603     else
604     {
605         InternalTargetsTreeMethods.Attach(ref
606             ↪ GetLinkIndexPartReference(target).RootAsTarget, linkIndex);
607     }
608 }
609 return linkIndex;
610 }
611
612 /// <remarks>
613 /// TODO: Возможно нужно будет заполнение нулями, если внешнее API ими не заполняет
614 ↪ пространство
615 /// </remarks>
616 [MethodImpl(MethodImplOptions.AggressiveInlining)]
617 public virtual TLink Create(ICollection<TLink> restrictions)
618 {
619     ref var header = ref GetHeaderReference();
620     var freeLink = header.FirstFreeLink;
621     if (!AreEqual(freeLink, Constants.Null))
622     {
623         UnusedLinksListMethods.Detach(freeLink);
624     }
625     else
626     {
627         var maximumPossibleInnerReference = Constants.InternalReferencesRange.Maximum;
628         if (GreaterThan(header.AllocatedLinks, maximumPossibleInnerReference))
629         {
630             throw new LinksLimitReachedException<TLink>(maximumPossibleInnerReference);
631         }
632         if (GreaterOrEqualThan(header.AllocatedLinks, Decrement(header.ReservedLinks)))
633         {
634             _dataMemory.ReservedCapacity += _dataMemory.ReservationStepInBytes;
635             _indexMemory.ReservedCapacity += _indexMemory.ReservationStepInBytes;
636             SetPointers(_dataMemory, _indexMemory);
637             header = ref GetHeaderReference();
638             header.ReservedLinks = ConvertToAddress(_dataMemory.ReservedCapacity /
639                 ↪ LinkDataPartSizeInBytes);
640         }
641         freeLink = header.AllocatedLinks = Increment(header.AllocatedLinks);
642         _dataMemory.UsedCapacity += LinkDataPartSizeInBytes;
643         _indexMemory.UsedCapacity += LinkIndexPartSizeInBytes;
644     }
645     return freeLink;
646 }
647
648 [MethodImpl(MethodImplOptions.AggressiveInlining)]
649 public virtual void Delete(ICollection<TLink> restrictions)
650 {
651     ref var header = ref GetHeaderReference();
652     var link = restrictions[Constants.IndexPart];
653     if (LessThan(link, header.AllocatedLinks)
654     {
655         UnusedLinksListMethods.AttachAsFirst(link);
656     }
657     else if (AreEqual(link, header.AllocatedLinks))
658     {
659         header.AllocatedLinks = Decrement(header.AllocatedLinks);
660         _dataMemory.UsedCapacity -= LinkDataPartSizeInBytes;
661         _indexMemory.UsedCapacity -= LinkIndexPartSizeInBytes;
662         // Убираем все связи, находящиеся в списке свободных в конце файла, до тех пор,
663         ↪ пока не дойдём до первой существующей связи
664         // Позволяет оптимизировать количество выделенных связей (AllocatedLinks)
665         while (GreaterThan(header.AllocatedLinks, GetZero()) &&
666             ↪ IsUnusedLink(header.AllocatedLinks))

```

```

661         {
662             UnusedLinksListMethods.Detach(header.AllocatedLinks);
663             header.AllocatedLinks = Decrement(header.AllocatedLinks);
664             _dataMemory.UsedCapacity -= LinkDataPartSizeInBytes;
665             _indexMemory.UsedCapacity -= LinkIndexPartSizeInBytes;
666         }
667     }
668 }
669
670 [MethodImpl(MethodImplOptions.AggressiveInlining)]
671 public IList<TLink> GetLinkStruct(TLink linkIndex)
672 {
673     ref var link = ref GetLinkDataPartReference(linkIndex);
674     return new Link<TLink>(linkIndex, link.Source, link.Target);
675 }
676
677 /// <remarks>
678 /// TODO: Возможно это должно быть событием, вызываемым из IMemory, в том случае, если
679 /// ↪ адрес реально поменялся
680 ///
681 /// Указатель this.links может быть в том же месте,
682 /// так как 0-я связь не используется и имеет такой же размер как Header,
683 /// поэтому header размещается в том же месте, что и 0-я связь
684 /// </remarks>
685 [MethodImpl(MethodImplOptions.AggressiveInlining)]
686 protected abstract void SetPointers(IResizableDirectMemory dataMemory,
687     ↪ IResizableDirectMemory indexMemory);
688
689 [MethodImpl(MethodImplOptions.AggressiveInlining)]
690 protected virtual void ResetPointers()
691 {
692     InternalSourcesListMethods = null;
693     InternalSourcesTreeMethods = null;
694     ExternalSourcesTreeMethods = null;
695     InternalTargetsTreeMethods = null;
696     ExternalTargetsTreeMethods = null;
697     UnusedLinksListMethods = null;
698 }
699
700 [MethodImpl(MethodImplOptions.AggressiveInlining)]
701 protected abstract ref LinksHeader<TLink> GetHeaderReference();
702
703 [MethodImpl(MethodImplOptions.AggressiveInlining)]
704 protected abstract ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex);
705
706 [MethodImpl(MethodImplOptions.AggressiveInlining)]
707 protected abstract ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
708     ↪ linkIndex);
709
710 [MethodImpl(MethodImplOptions.AggressiveInlining)]
711 protected virtual bool Exists(TLink link)
712     => GreaterOrEqualThan(link, Constants.InternalReferencesRange.Minimum)
713     && LessOrEqualThan(link, GetHeaderReference().AllocatedLinks)
714     && !IsUnusedLink(link);
715
716 [MethodImpl(MethodImplOptions.AggressiveInlining)]
717 protected virtual bool IsUnusedLink(TLink linkIndex)
718 {
719     if (!AreEqual(GetHeaderReference().FirstFreeLink, linkIndex)) // May be this check
720         ↪ is not needed
721     {
722         // TODO: Reduce access to memory in different location (should be enough to use
723         ↪ just linkIndexPart)
724         ref var linkDataPart = ref GetLinkDataPartReference(linkIndex);
725         ref var linkIndexPart = ref GetLinkIndexPartReference(linkIndex);
726         return AreEqual(linkIndexPart.SizeAsTarget, default) &&
727             ↪ !AreEqual(linkDataPart.Source, default);
728     }
729     else
730     {
731         return true;
732     }
733 }
734
735 [MethodImpl(MethodImplOptions.AggressiveInlining)]
736 protected virtual TLink GetOne() => _one;
737
738 [MethodImpl(MethodImplOptions.AggressiveInlining)]
739 protected virtual TLink GetZero() => default;

```



```

734 [MethodImpl(MethodImplOptions.AggressiveInlining)]
735 protected virtual bool AreEqual(TLink first, TLink second) =>
736     ↪ _equalityComparer.Equals(first, second);
737
738 [MethodImpl(MethodImplOptions.AggressiveInlining)]
739 protected virtual bool LessThan(TLink first, TLink second) => _comparer.Compare(first,
740     ↪ second) < 0;
741
742 [MethodImpl(MethodImplOptions.AggressiveInlining)]
743 protected virtual bool LessOrEqualThan(TLink first, TLink second) =>
744     ↪ _comparer.Compare(first, second) <= 0;
745
746 [MethodImpl(MethodImplOptions.AggressiveInlining)]
747 protected virtual bool GreaterThan(TLink first, TLink second) =>
748     ↪ _comparer.Compare(first, second) > 0;
749
750 [MethodImpl(MethodImplOptions.AggressiveInlining)]
751 protected virtual long ConvertToInt64(TLink value) =>
752     ↪ _addressToInt64Converter.Convert(value);
753
754 [MethodImpl(MethodImplOptions.AggressiveInlining)]
755 protected virtual TLink ConvertToAddress(long value) =>
756     ↪ _int64ToAddressConverter.Convert(value);
757
758 [MethodImpl(MethodImplOptions.AggressiveInlining)]
759 protected virtual TLink Add(TLink first, TLink second) => Arithmetic<TLink>.Add(first,
760     ↪ second);
761
762 [MethodImpl(MethodImplOptions.AggressiveInlining)]
763 protected virtual TLink Subtract(TLink first, TLink second) =>
764     ↪ Arithmetic<TLink>.Subtract(first, second);
765
766 [MethodImpl(MethodImplOptions.AggressiveInlining)]
767 protected virtual TLink Increment(TLink link) => Arithmetic<TLink>.Increment(link);
768
769 [MethodImpl(MethodImplOptions.AggressiveInlining)]
770 protected virtual TLink Decrement(TLink link) => Arithmetic<TLink>.Decrement(link);
771
772 #region Disposable
773
774 protected override bool AllowMultipleDisposeCalls
775 {
776     [MethodImpl(MethodImplOptions.AggressiveInlining)]
777     get => true;
778 }
779
780 [MethodImpl(MethodImplOptions.AggressiveInlining)]
781 protected override void Dispose(bool manual, bool wasDisposed)
782 {
783     if (!wasDisposed)
784     {
785         ResetPointers();
786         _dataMemory.DisposeIfPossible();
787         _indexMemory.DisposeIfPossible();
788     }
789 }
790
791 #endregion
792 }

```

1.46 ./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> :
11         ↪ AbsoluteCircularDoublyLinkedListMethods<TLink>, ILinksListMethods<TLink>
12     {

```

```

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 }

```

1.47 ./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 }

```

```

19     [MethodImpl(MethodImplOptions.AggressiveInlining)]
20     public override bool Equals(object obj) => obj is RawLinkDataPart<TLink> link ?
        ↳ 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>
        ↳ right) => left.Equals(right);
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     public static bool operator !=(RawLinkDataPart<TLink> left, RawLinkDataPart<TLink>
        ↳ right) => !(left == right);
35 }
36 }

```

1.48 ./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 =
            ↳ EqualityComparer<TLink>.Default;
13
14         public static readonly long SizeInBytes = Structure<RawLinkIndexPart<TLink>>.Size;
15
16         public TLink RootAsSource;
17         public TLink LeftAsSource;
18         public TLink RightAsSource;
19         public TLink SizeAsSource;
20         public TLink RootAsTarget;
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 RawLinkIndexPart<TLink> link ?
            ↳ Equals(link) : false;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public bool Equals(RawLinkIndexPart<TLink> other)
30             => _equalityComparer.Equals(RootAsSource, other.RootAsSource)
31             && _equalityComparer.Equals(LeftAsSource, other.LeftAsSource)
32             && _equalityComparer.Equals(RightAsSource, other.RightAsSource)
33             && _equalityComparer.Equals(SizeAsSource, other.SizeAsSource)
34             && _equalityComparer.Equals(RootAsTarget, other.RootAsTarget)
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() => (RootAsSource, LeftAsSource, RightAsSource,
            ↳ SizeAsSource, RootAsTarget, LeftAsTarget, RightAsTarget, SizeAsTarget).GetHashCode();
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public static bool operator ==(RawLinkIndexPart<TLink> left, RawLinkIndexPart<TLink>
            ↳ right) => left.Equals(right);
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public static bool operator !=(RawLinkIndexPart<TLink> left, RawLinkIndexPart<TLink>
            ↳ right) => !(left == right);
47     }
48 }

```

1.49 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksRecursionlessSizeBalancedTree

```

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 UInt32ExternalLinksRecursionlessSizeBalancedTreeMethodsBase :
10         ↳ ExternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink>, ILinksTreeMethods<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
18         ↳ UInt32ExternalLinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink>
19         ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
20         ↳ linksIndexParts, LinksHeader<TLink>* header)
21         : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
22         {
23             LinksDataParts = linksDataParts;
24             LinksIndexParts = linksIndexParts;
25             Header = header;
26         }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetZero() => 0U;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override bool EqualToZero(TLink value) => value == 0U;
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected override bool AreEqual(TLink first, TLink second) => first == second;
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected override bool GreaterThanZero(TLink value) => value > 0U;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override bool GreaterThan(TLink first, TLink second) => first > second;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override bool GreaterOrEqualThanZero(TLink value) => true; // value >= 0 is
48         ↳ always true for ulong
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override bool LessOrEqualThanZero(TLink value) => value == 0UL; // value is
52         ↳ always >= 0 for ulong
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected override bool LessOrEqualThan(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 LinksHeader<TLink> GetHeaderReference() => ref *Header;
71
72         [MethodImpl(MethodImplOptions.AggressiveInlining)]
73         protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
74         ↳ ref LinksDataParts[link];
75     }
76 }

```

```

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

```

1.50 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksSizeBalancedTreeMethodsBase

```

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 UInt32ExternalLinksSizeBalancedTreeMethodsBase :
        ↪ 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 UInt32ExternalLinksSizeBalancedTreeMethodsBase(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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override TLink GetZero() => 0U;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override bool EqualToZero(TLink value) => value == 0U;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override bool AreEqual(TLink first, TLink second) => first == second;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override bool GreaterThanZero(TLink value) => value > 0U;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override bool GreaterThan(TLink first, TLink second) => first > second;
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         protected override bool GreaterOrEqualThanZero(TLink value) => true; // value >= 0 is
        ↪ always true for ulong
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         protected override bool LessOrEqualThanZero(TLink value) => value == 0UL; // value is
        ↪ always >= 0 for ulong
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;
49
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 LinksHeader<TLink> GetHeaderReference() => ref *Header;
71
72 [MethodImpl(MethodImplOptions.AggressiveInlining)]
73 protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
   ↳ ref LinksDataParts[link];
74
75 [MethodImpl(MethodImplOptions.AggressiveInlining)]
76 protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
   ↳ ref LinksIndexParts[link];
77
78 [MethodImpl(MethodImplOptions.AggressiveInlining)]
79 protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
80 {
81     ref var firstLink = ref LinksDataParts[first];
82     ref var secondLink = ref LinksDataParts[second];
83     return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
   ↳ secondLink.Source, secondLink.Target);
84 }
85
86 [MethodImpl(MethodImplOptions.AggressiveInlining)]
87 protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
88 {
89     ref var firstLink = ref LinksDataParts[first];
90     ref var secondLink = ref LinksDataParts[second];
91     return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
   ↳ secondLink.Source, secondLink.Target);
92 }
93 }
94 }

```

1.51 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksSourcesRecursionlessSizeBalance

```

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 UInt32ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods :
   ↳ UInt32ExternalLinksRecursionlessSizeBalancedTreeMethodsBase
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public
   ↳ UInt32ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(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) =>
27         ↳ LinksIndexParts[node].LeftAsSource = left;
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected override void SetRight(TLink node, TLink right) =>
31         ↳ LinksIndexParts[node].RightAsSource = right;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override void SetSize(TLink node, TLink size) =>
38         ↳ LinksIndexParts[node].SizeAsSource = size;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetTreeRoot() => Header->RootAsSource;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
48         ↳ TLink secondSource, TLink secondTarget)
49         => firstSource < secondSource || firstSource == secondSource && firstTarget <
50             ↳ secondTarget;
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
54         ↳ TLink secondSource, TLink secondTarget)
55         => firstSource > secondSource || firstSource == secondSource && firstTarget >
56             ↳ secondTarget;
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     protected override void ClearNode(TLink node)
60     {
61         ref var link = ref LinksIndexParts[node];
62         link.LeftAsSource = Zero;
63         link.RightAsSource = Zero;
64         link.SizeAsSource = Zero;
65     }
66 }

```

1.52 ./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)]

```

```

26     protected override void SetLeft(TLink node, TLink left) =>
27         ↳ LinksIndexParts[node].LeftAsSource = left;
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected override void SetRight(TLink node, TLink right) =>
31         ↳ LinksIndexParts[node].RightAsSource = right;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override void SetSize(TLink node, TLink size) =>
38         ↳ LinksIndexParts[node].SizeAsSource = size;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetTreeRoot() => Header->RootAsSource;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
48         ↳ TLink secondSource, TLink secondTarget)
49         => firstSource < secondSource || firstSource == secondSource && firstTarget <
50             ↳ secondTarget;
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
54         ↳ TLink secondSource, TLink secondTarget)
55         => firstSource > secondSource || firstSource == secondSource && firstTarget >
56             ↳ secondTarget;
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     protected override void ClearNode(TLink node)
60     {
61         ref var link = ref LinksIndexParts[node];
62         link.LeftAsSource = Zero;
63         link.RightAsSource = Zero;
64         link.SizeAsSource = Zero;
65     }
66 }

```

1.53 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksTargetsRecursionlessSizeBalance

```

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 UInt32ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods :
9          ↳ UInt32ExternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public
13         ↳ UInt32ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
14         ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
15         ↳ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
16         ↳ linksIndexParts, header) { }
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref TLink GetLeftReference(TLink node) => ref
20         ↳ LinksIndexParts[node].LeftAsTarget;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ref TLink GetRightReference(TLink node) => ref
24         ↳ LinksIndexParts[node].RightAsTarget;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetLeft(TLink node, TLink left) =>
34         ↳ LinksIndexParts[node].LeftAsTarget = left;
35
36

```



```

28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override void SetRight(TLink node, TLink right) =>
        ↳ LinksIndexParts[node].RightAsTarget = right;
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override void SetSize(TLink node, TLink size) =>
        ↳ LinksIndexParts[node].SizeAsTarget = size;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override TLink GetTreeRoot() => Header->RootAsTarget;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
        ↳ TLink secondSource, TLink secondTarget)
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 }

```

1.54 ./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     }
40 }

```

```

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

```

1.55 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksRecursionlessSizeBalancedTreeM

```

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 UInt32InternalLinksRecursionlessSizeBalancedTreeMethodsBase :
10         ↳ InternalLinksRecursionlessSizeBalancedTreeMethodsBase<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
18         ↳ UInt32InternalLinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink>
19         ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
20         ↳ linksIndexParts, LinksHeader<TLink>* header)
21         : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
22         {
23             LinksDataParts = linksDataParts;
24             LinksIndexParts = linksIndexParts;
25             Header = header;
26         }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override TLink GetZero() => 0U;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override bool EqualToZero(TLink value) => value == 0U;
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected override bool AreEqual(TLink first, TLink second) => first == second;
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected override bool GreaterThanZero(TLink value) => value > 0U;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override bool GreaterThan(TLink first, TLink second) => first > second;
42
43         [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) =>
    ↳ 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 FirstIsToTheLeftOfSecond(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 }

```

1.56 ./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
44     ↪ always true for ulong
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override bool LessOrEqualThanZero(TLink value) => value == 0UL; // value is
48     ↪ always >= 0 for ulong
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     protected override bool LessThanZero(TLink value) => false; // value < 0 is always false
55     ↪ for ulong
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override bool LessThan(TLink first, TLink second) => first < second;
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override TLink Increment(TLink value) => ++value;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override TLink Decrement(TLink value) => --value;
65
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     protected override TLink Add(TLink first, TLink second) => first + second;
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override TLink Subtract(TLink first, TLink second) => first - second;
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
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     ↪ GetKeyPartValue(first) < GetKeyPartValue(second);
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
86     ↪ GetKeyPartValue(first) > GetKeyPartValue(second);
87 }
88 }

```

1.57 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSourcesLinkedListMethods.cs

```

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.Generic
7  {
8      public unsafe class UInt32InternalLinksSourcesLinkedListMethods :
9      ↪ InternalLinksSourcesLinkedListMethods<TLink>
10     {
11         private readonly RawLinkDataPart<TLink>* _linksDataParts;
12         private readonly RawLinkIndexPart<TLink>* _linksIndexParts;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public UInt32InternalLinksSourcesLinkedListMethods(LinksConstants<TLink> constants,
16         ↪ RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>* linksIndexParts)

```

```

15         : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts)
16     {
17         _linksDataParts = linksDataParts;
18         _linksIndexParts = linksIndexParts;
19     }
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
23         ↪ ref _linksDataParts[link];
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
27         ↪ ref _linksIndexParts[link];
28 }

```

1.58 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSourcesRecursionlessSizeBalance

```

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 UInt32InternalLinksSourcesRecursionlessSizeBalancedTreeMethods :
9          ↪ UInt32InternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public
13             ↪ UInt32InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
14             ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
15             ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
16             ↪ linksIndexParts, header) { }
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref TLink GetLeftReference(TLink node) => ref
20             ↪ LinksIndexParts[node].LeftAsSource;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ref TLink GetRightReference(TLink node) => ref
24             ↪ LinksIndexParts[node].RightAsSource;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsSource;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsSource;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetLeft(TLink node, TLink left) =>
34             ↪ LinksIndexParts[node].LeftAsSource = left;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override void SetRight(TLink node, TLink right) =>
38             ↪ LinksIndexParts[node].RightAsSource = right;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override void SetSize(TLink node, TLink size) =>
45             ↪ LinksIndexParts[node].SizeAsSource = size;
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsSource;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Target;
55
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]
57         protected override void ClearNode(TLink node)
58         {
59             ref var link = ref LinksIndexParts[node];
60             link.LeftAsSource = Zero;
61             link.RightAsSource = Zero;
62             link.SizeAsSource = Zero;
63         }
64     }
65 }

```

```

53     }
54
55     public override TLink Search(TLink source, TLink target) =>
56         ↪ SearchCore(GetTreeRoot(source), target);
57 }

```

1.59 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSourcesSizeBalancedTreeMethod

```

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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsSource;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]
53         protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Target;
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
64         public override TLink Search(TLink source, TLink target) =>
65             ↪ SearchCore(GetTreeRoot(source), target);
66     }
67 }

```

1.60 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksTargetsRecursionlessSizeBalanc

```

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 UInt32InternalLinksTargetsRecursionlessSizeBalancedTreeMethods :
9         ↳ UInt32InternalLinksRecursionlessSizeBalancedTreeMethodsBase
10    {
11        [MethodImpl(MethodImplOptions.AggressiveInlining)]
12        public
13            ↳ UInt32InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
14            ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
15            ↳ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
16            ↳ linksIndexParts, header) { }
17
18        [MethodImpl(MethodImplOptions.AggressiveInlining)]
19        protected override ref TLink GetLeftReference(TLink node) => ref
20            ↳ LinksIndexParts[node].LeftAsTarget;
21
22        [MethodImpl(MethodImplOptions.AggressiveInlining)]
23        protected override ref TLink GetRightReference(TLink node) => ref
24            ↳ LinksIndexParts[node].RightAsTarget;
25
26        [MethodImpl(MethodImplOptions.AggressiveInlining)]
27        protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
28
29        [MethodImpl(MethodImplOptions.AggressiveInlining)]
30        protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
31
32        [MethodImpl(MethodImplOptions.AggressiveInlining)]
33        protected override void SetLeft(TLink node, TLink left) =>
34            ↳ LinksIndexParts[node].LeftAsTarget = left;
35
36        [MethodImpl(MethodImplOptions.AggressiveInlining)]
37        protected override void SetRight(TLink node, TLink right) =>
38            ↳ LinksIndexParts[node].RightAsTarget = right;
39
40        [MethodImpl(MethodImplOptions.AggressiveInlining)]
41        protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
42
43        [MethodImpl(MethodImplOptions.AggressiveInlining)]
44        protected override void SetSize(TLink node, TLink size) =>
45            ↳ LinksIndexParts[node].SizeAsTarget = size;
46
47        [MethodImpl(MethodImplOptions.AggressiveInlining)]
48        protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsTarget;
49
50        [MethodImpl(MethodImplOptions.AggressiveInlining)]
51        protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
52
53        [MethodImpl(MethodImplOptions.AggressiveInlining)]
54        protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Source;
55
56        [MethodImpl(MethodImplOptions.AggressiveInlining)]
57        protected override void ClearNode(TLink node)
58        {
59            ref var link = ref LinksIndexParts[node];
60            link.LeftAsTarget = Zero;
61            link.RightAsTarget = Zero;
62            link.SizeAsTarget = Zero;
63        }
64
65        public override TLink Search(TLink source, TLink target) =>
66            ↳ SearchCore(GetTreeRoot(target), source);
67    }
68 }

```

1.61 ./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)]

```

```

11 public UInt32InternalLinksTargetsSizeBalancedTreeMethods(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].LeftAsTarget;
15
16 [MethodImpl(MethodImplOptions.AggressiveInlining)]
17 protected override ref TLink GetRightReference(TLink node) => ref
    ↳ LinksIndexParts[node].RightAsTarget;
18
19 [MethodImpl(MethodImplOptions.AggressiveInlining)]
20 protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
21
22 [MethodImpl(MethodImplOptions.AggressiveInlining)]
23 protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
24
25 [MethodImpl(MethodImplOptions.AggressiveInlining)]
26 protected override void SetLeft(TLink node, TLink left) =>
    ↳ LinksIndexParts[node].LeftAsTarget = left;
27
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 protected override void SetRight(TLink node, TLink right) =>
    ↳ LinksIndexParts[node].RightAsTarget = right;
30
31 [MethodImpl(MethodImplOptions.AggressiveInlining)]
32 protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
33
34 [MethodImpl(MethodImplOptions.AggressiveInlining)]
35 protected override void SetSize(TLink node, TLink size) =>
    ↳ LinksIndexParts[node].SizeAsTarget = size;
36
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) =>
    ↳ SearchCore(GetTreeRoot(target), source);
56 }
57 }

```

1.62 ./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
    ↳ indexMemory) : this(dataMemory, indexMemory, DefaultLinksSizeStep) { }
24
25 [MethodImpl(MethodImplOptions.AggressiveInlining)]
26 public UInt32SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
    ↳ memoryReservationStep, Default<LinksConstants<TLink>>.Instance,
    ↳ IndexTreeType.Default, useLinkedList: true) { }
27
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 public UInt32SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants) :
    ↳ this(dataMemory, indexMemory, memoryReservationStep, constants,
    ↳ IndexTreeType.Default, useLinkedList: true) { }
30
31 [MethodImpl(MethodImplOptions.AggressiveInlining)]
32 public UInt32SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants,
    ↳ IndexTreeType indexTreeType, bool useLinkedList) : base(dataMemory, indexMemory,
    ↳ memoryReservationStep, constants, useLinkedList)
33 {
34     if (indexTreeType == IndexTreeType.SizeBalancedTree)
35     {
36         _createInternalSourceTreeMethods = () => new
            ↳ UInt32InternalLinksSourcesSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
37         _createExternalSourceTreeMethods = () => new
            ↳ UInt32ExternalLinksSourcesSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
38         _createInternalTargetTreeMethods = () => new
            ↳ UInt32InternalLinksTargetsSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
39         _createExternalTargetTreeMethods = () => new
            ↳ UInt32ExternalLinksTargetsSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
40     }
41     else
42     {
43         _createInternalSourceTreeMethods = () => new
            ↳ UInt32InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
44         _createExternalSourceTreeMethods = () => new
            ↳ UInt32ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
45         _createInternalTargetTreeMethods = () => new
            ↳ UInt32InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
46         _createExternalTargetTreeMethods = () => new
            ↳ UInt32ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
47     }
48     Init(dataMemory, indexMemory);
49 }
50
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected override void SetPointers(IResizableDirectMemory dataMemory,
    ↳ IResizableDirectMemory indexMemory)
53 {
54     _linksDataParts = (RawLinkDataPart<TLink>*)dataMemory.Pointer;
55     _linksIndexParts = (RawLinkIndexPart<TLink>*)indexMemory.Pointer;
56     _header = (LinksHeader<TLink>*)indexMemory.Pointer;
57     if (_useLinkedList)
58     {
59         InternalSourcesListMethods = new
            ↳ UInt32InternalLinksSourcesLinkedListMethods(Constants, _linksDataParts,
            ↳ _linksIndexParts);
60     }
61     else
62     {
63         InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
64     }
65     ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
66     InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
67     ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
68     UnusedLinksListMethods = new UInt32UnusedLinksListMethods(_linksDataParts, _header);
69 }
70

```

```

71 [MethodImpl(MethodImplOptions.AggressiveInlining)]
72 protected override void ResetPointers()
73 {
74     base.ResetPointers();
75     _linksDataParts = null;
76     _linksIndexParts = null;
77     _header = null;
78 }
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
82
83 [MethodImpl(MethodImplOptions.AggressiveInlining)]
84 protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
85     => ref _linksDataParts[linkIndex];
86
87 [MethodImpl(MethodImplOptions.AggressiveInlining)]
88 protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
89     linkIndex) => ref _linksIndexParts[linkIndex];
90
91 [MethodImpl(MethodImplOptions.AggressiveInlining)]
92 protected override bool AreEqual(TLink first, TLink second) => first == second;
93
94 [MethodImpl(MethodImplOptions.AggressiveInlining)]
95 protected override bool LessThan(TLink first, TLink second) => first < second;
96
97 [MethodImpl(MethodImplOptions.AggressiveInlining)]
98 protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;
99
100 [MethodImpl(MethodImplOptions.AggressiveInlining)]
101 protected override bool GreaterThan(TLink first, TLink second) => first > second;
102
103 [MethodImpl(MethodImplOptions.AggressiveInlining)]
104 protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;
105
106 [MethodImpl(MethodImplOptions.AggressiveInlining)]
107 protected override TLink GetZero() => 0U;
108
109 [MethodImpl(MethodImplOptions.AggressiveInlining)]
110 protected override TLink GetOne() => 1U;
111
112 [MethodImpl(MethodImplOptions.AggressiveInlining)]
113 protected override long ConvertToInt64(TLink value) => value;
114
115 [MethodImpl(MethodImplOptions.AggressiveInlining)]
116 protected override TLink ConvertToAddress(long value) => (TLink)value;
117
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 protected override TLink Add(TLink first, TLink second) => first + second;
120
121 [MethodImpl(MethodImplOptions.AggressiveInlining)]
122 protected override TLink Subtract(TLink first, TLink second) => first - second;
123
124 [MethodImpl(MethodImplOptions.AggressiveInlining)]
125 protected override TLink Increment(TLink link) => ++link;
126
127 [MethodImpl(MethodImplOptions.AggressiveInlining)]
128 protected override TLink Decrement(TLink link) => --link;
129 }
130 }

```

1.63 ./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
20

```

```

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

```

1.64 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksRecursionlessSizeBalancedTree

```

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 UInt64ExternalLinksRecursionlessSizeBalancedTreeMethodsBase :
10         ↪ ExternalLinksRecursionlessSizeBalancedTreeMethodsBase<TLink>, ILinksTreeMethods<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
18         ↪ UInt64ExternalLinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink>
19         ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
20         ↪ linksIndexParts, LinksHeader<TLink>* header)
21         : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
22     {
23         LinksDataParts = linksDataParts;
24         LinksIndexParts = linksIndexParts;
25         Header = header;
26     }
27
28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override ulong GetZero() => 0UL;
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override bool EqualToZero(ulong value) => value == 0UL;
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override bool AreEqual(ulong first, ulong second) => first == second;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override bool GreaterThanZero(ulong value) => value > 0UL;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     protected override bool GreaterThan(ulong first, ulong second) => first > second;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
48         ↪ always true for ulong
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
52         ↪ always >= 0 for ulong
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
59         ↪ for ulong
60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     protected override bool LessThan(ulong first, ulong second) => first < second;
63
64     [MethodImpl(MethodImplOptions.AggressiveInlining)]
65     protected override ulong Increment(ulong value) => ++value;
66 }

```

```

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 LinksHeader<TLink> GetHeaderReference() => ref *Header;
71
72 [MethodImpl(MethodImplOptions.AggressiveInlining)]
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 FirstIsToLeftOfSecond(TLink first, TLink second)
82 {
83     ref var firstLink = ref LinksDataParts[first];
84     ref var secondLink = ref LinksDataParts[second];
85     return FirstIsToLeftOfSecond(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 }

```

1.65 ./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 :
10         ↪ ExternalLinksSizeBalancedTreeMethodsBase<TLink>, ILinksTreeMethods<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 UInt64ExternalLinksSizeBalancedTreeMethodsBase(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() => 0UL;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         protected override bool EqualToZero(ulong value) => value == 0UL;
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 > 0UL;
38
39         [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
44     ↪ always true for ulong
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
48     ↪ always >= 0 for ulong
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
55     ↪ for ulong
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override bool LessThan(ulong first, ulong second) => first < second;
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override ulong Increment(ulong value) => ++value;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override ulong Decrement(ulong value) => --value;
65
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     protected override ulong Add(ulong first, ulong second) => first + second;
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override ulong Subtract(ulong first, ulong second) => first - second;
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     protected override ref TLink GetHeaderReference() => ref *Header;
74
75     [MethodImpl(MethodImplOptions.AggressiveInlining)]
76     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
77     ↪ ref LinksDataParts[link];
78
79     [MethodImpl(MethodImplOptions.AggressiveInlining)]
80     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
81     ↪ ref LinksIndexParts[link];
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override bool FirstIsToLeftOfSecond(TLink first, TLink second)
85     {
86         ref var firstLink = ref LinksDataParts[first];
87         ref var secondLink = ref LinksDataParts[second];
88         return FirstIsToLeftOfSecond(firstLink.Source, firstLink.Target,
89         ↪ secondLink.Source, secondLink.Target);
90     }
91
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
94     {
95         ref var firstLink = ref LinksDataParts[first];
96         ref var secondLink = ref LinksDataParts[second];
97         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
98         ↪ secondLink.Source, secondLink.Target);
99     }
100 }

```

1.66 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods

```

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 UInt64ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods :
9      ↪ UInt64ExternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

11 public
12     ↳ UInt64ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(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 [MethodImpl(MethodImplOptions.AggressiveInlining)]
53 protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
54     ↳ TLink secondSource, TLink secondTarget)
55     => firstSource < secondSource || firstSource == secondSource && firstTarget <
56     ↳ secondTarget;
57
58 [MethodImpl(MethodImplOptions.AggressiveInlining)]
59 protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
60     ↳ TLink secondSource, TLink secondTarget)
61     => firstSource > secondSource || firstSource == secondSource && firstTarget >
62     ↳ secondTarget;
63
64 [MethodImpl(MethodImplOptions.AggressiveInlining)]
65 protected override void ClearNode(TLink node)
66 {
67     ref var link = ref LinksIndexParts[node];
68     link.LeftAsSource = Zero;
69     link.RightAsSource = Zero;
70     link.SizeAsSource = Zero;
71 }
72 }
73 }

```

1.67 ./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 }

```

```

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

```

1.68 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods

```

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 UInt64ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods :
9     ↪ UInt64ExternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public
13         ↪ UInt64ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
14         ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
15         ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
16         ↪ linksIndexParts, header) { }
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

14     protected override ref TLink GetLeftReference(TLink node) => ref
15         ↳ LinksIndexParts[node].LeftAsTarget;
16
17     [MethodImpl(MethodImplOptions.AggressiveInlining)]
18     protected override ref TLink GetRightReference(TLink node) => ref
19         ↳ LinksIndexParts[node].RightAsTarget;
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override void SetLeft(TLink node, TLink left) =>
29         ↳ LinksIndexParts[node].LeftAsTarget = left;
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override void SetRight(TLink node, TLink right) =>
33         ↳ LinksIndexParts[node].RightAsTarget = right;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override void SetSize(TLink node, TLink size) =>
40         ↳ LinksIndexParts[node].SizeAsTarget = size;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override TLink GetTreeRoot() => Header->RootAsTarget;
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override bool FirstIsToTheLeftOfSecond(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 bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
56         ↳ TLink secondSource, TLink secondTarget)
57         => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
58         ↳ secondSource;
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override void ClearNode(TLink node)
62     {
63         ref var link = ref LinksIndexParts[node];
64         link.LeftAsTarget = Zero;
65         link.RightAsTarget = Zero;
66         link.SizeAsTarget = Zero;
67     }
68 }
69
70 }

```

1.69 ./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)]

```



```

17     protected override ref TLink GetRightReference(TLink node) => ref
18         ↳ LinksIndexParts[node].RightAsTarget;
19
20     [MethodImpl(MethodImplOptions.AggressiveInlining)]
21     protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
25
26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     protected override void SetLeft(TLink node, TLink left) =>
28         ↳ LinksIndexParts[node].LeftAsTarget = left;
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     protected override void SetRight(TLink node, TLink right) =>
32         ↳ LinksIndexParts[node].RightAsTarget = right;
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override void SetSize(TLink node, TLink size) =>
39         ↳ LinksIndexParts[node].SizeAsTarget = size;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override TLink GetTreeRoot() => Header->RootAsTarget;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override bool FirstIsToLeftOfSecond(TLink firstSource, TLink firstTarget,
49         ↳ TLink secondSource, TLink secondTarget)
50         => firstTarget < secondTarget || firstTarget == secondTarget && firstSource <
51             ↳ secondSource;
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
55         ↳ TLink secondSource, TLink secondTarget)
56         => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
57             ↳ secondSource;
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     protected override void ClearNode(TLink node)
61     {
62         ref var link = ref LinksIndexParts[node];
63         link.LeftAsTarget = Zero;
64         link.RightAsTarget = Zero;
65         link.SizeAsTarget = Zero;
66     }
67 }

```

1.70 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksRecursionlessSizeBalancedTreeM

```

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 UInt64InternalLinksRecursionlessSizeBalancedTreeMethodsBase :
10         ↳ InternalLinksRecursionlessSizeBalancedTreeMethodsBase<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
18             ↳ UInt64InternalLinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink>
19             ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
20             ↳ linksIndexParts, LinksHeader<TLink>* header)
21             : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
22          {
23              LinksDataParts = linksDataParts;
24              LinksIndexParts = linksIndexParts;
25              Header = header;
26          }
27      }
28  }

```

```

23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected override ulong GetZero() => OUL;
25
26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     protected override bool EqualToZero(ulong value) => value == OUL;
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected override bool AreEqual(ulong first, ulong second) => first == second;
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     protected override bool GreaterThanZero(ulong value) => value > OUL;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override bool GreaterThan(ulong first, ulong second) => first > second;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
43     ↪ always true for ulong
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool LessOrEqualThanZero(ulong value) => value == OUL; // value is
47     ↪ always >= 0 for ulong
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
54     ↪ for ulong
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     protected override bool LessThan(ulong first, ulong second) => first < second;
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     protected override ulong Increment(ulong value) => ++value;
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     protected override ulong Decrement(ulong value) => --value;
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override ulong Add(ulong first, ulong second) => first + second;
67
68     [MethodImpl(MethodImplOptions.AggressiveInlining)]
69     protected override ulong Subtract(ulong first, ulong second) => first - second;
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 FirstIsToLeftOfSecond(TLink first, TLink second) =>
81     ↪ GetKeyPartValue(first) < GetKeyPartValue(second);
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
85     ↪ GetKeyPartValue(first) > GetKeyPartValue(second);
86 }
87 }

```

1.71 ./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     {

```

```

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 UInt64 InternalLinksSizeBalancedTreeMethodsBase(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 ulong GetZero() => 0UL;
26
27 [MethodImpl(MethodImplOptions.AggressiveInlining)]
28 protected override bool EqualToZero(ulong value) => value == 0UL;
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 > 0UL;
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 == 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 }

1.72 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSourcesLinkedListMethods.cs

```
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.Generic
7 {
8     public unsafe class UInt64InternalLinksSourcesLinkedListMethods :
9         ↪ InternalLinksSourcesLinkedListMethods<TLink>
10     {
11         private readonly RawLinkDataPart<TLink>* _linksDataParts;
12         private readonly RawLinkIndexPart<TLink>* _linksIndexParts;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public UInt64InternalLinksSourcesLinkedListMethods(LinksConstants<TLink> constants,
16             ↪ RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>* linksIndexParts)
17             : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts)
18         {
19             _linksDataParts = linksDataParts;
20             _linksIndexParts = linksIndexParts;
21         }
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
25             ↪ ref _linksDataParts[link];
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
29             ↪ ref _linksIndexParts[link];
30     }
31 }
```

1.73 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSourcesRecursionlessSizeBalance

```
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 UInt64InternalLinksSourcesRecursionlessSizeBalancedTreeMethods :
9         ↪ UInt64InternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public
13             ↪ UInt64InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
14             ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
15             ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
16             ↪ linksIndexParts, header) { }
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref TLink GetLeftReference(TLink node) => ref
20             ↪ LinksIndexParts[node].LeftAsSource;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ref TLink GetRightReference(TLink node) => ref
24             ↪ LinksIndexParts[node].RightAsSource;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsSource;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsSource;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetLeft(TLink node, TLink left) =>
34             ↪ LinksIndexParts[node].LeftAsSource = left;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override void SetRight(TLink node, TLink right) =>
38             ↪ LinksIndexParts[node].RightAsSource = right;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     }
```

```

35     protected override void SetSize(TLink node, TLink size) =>
36         ↳ LinksIndexParts[node].SizeAsSource = size;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsSource;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Target;
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override void ClearNode(TLink node)
49     {
50         ref var link = ref LinksIndexParts[node];
51         link.LeftAsSource = Zero;
52         link.RightAsSource = Zero;
53         link.SizeAsSource = Zero;
54     }
55
56     public override TLink Search(TLink source, TLink target) =>
57         ↳ SearchCore(GetTreeRoot(source), target);
58 }

```

1.74 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSourcesSizeBalancedTreeMethods

```

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 :
9          ↳ UInt64InternalLinksSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public UInt64InternalLinksSourcesSizeBalancedTreeMethods(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(TLink node) => LinksIndexParts[node].RootAsSource;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     }

```

```

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 }

```

1.75 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksTargetsRecursionlessSizeBalance

```

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 UInt64InternalLinksTargetsRecursionlessSizeBalancedTreeMethods :
9          ↪ UInt64InternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public
13         ↪ UInt64InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink>
14         ↪ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
15         ↪ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
16         ↪ linksIndexParts, header) { }
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref ulong GetLeftReference(ulong node) => ref
20         ↪ LinksIndexParts[node].LeftAsTarget;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ref ulong GetRightReference(ulong node) => ref
24         ↪ LinksIndexParts[node].RightAsTarget;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetLeft(TLink node, TLink left) =>
34         ↪ LinksIndexParts[node].LeftAsTarget = left;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override void SetRight(TLink node, TLink right) =>
38         ↪ LinksIndexParts[node].RightAsTarget = right;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override void SetSize(TLink node, TLink size) =>
45         ↪ LinksIndexParts[node].SizeAsTarget = size;
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsTarget;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Source;
55
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]
57         protected override void ClearNode(TLink node)
58         {
59             ref var link = ref LinksIndexParts[node];
60             link.LeftAsTarget = Zero;
61             link.RightAsTarget = Zero;
62             link.SizeAsTarget = Zero;
63         }
64     }
65 }

```

```

54
55     public override TLink Search(TLink source, TLink target) =>
        ↳ SearchCore(GetTreeRoot(target), source);
56 }
57 }

```

1.76 ./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         [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         protected override void ClearNode(TLink node)
57         {
58             ref var link = ref LinksIndexParts[node];
59             link.LeftAsTarget = Zero;
60             link.RightAsTarget = Zero;
61             link.SizeAsTarget = Zero;
62         }
63
64         public override TLink Search(TLink source, TLink target) =>
65             ↳ SearchCore(GetTreeRoot(target), source);
66     }
67 }

```

1.77 ./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             ↪ IndexTreeType.Default, useLinkedList: true) { }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public UInt64SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
34             ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants) :
35             ↪ this(dataMemory, indexMemory, memoryReservationStep, constants,
36             ↪ IndexTreeType.Default, useLinkedList: true) { }
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         public UInt64SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
40             ↪ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants,
41             ↪ IndexTreeType indexTreeType, bool useLinkedList) : base(dataMemory, indexMemory,
42             ↪ memoryReservationStep, constants, useLinkedList)
43         {
44             if (indexTreeType == IndexTreeType.SizeBalancedTree)
45             {
46                 _createInternalSourceTreeMethods = () => new
47                     ↪ UInt64InternalLinksSourcesSizeBalancedTreeMethods(Constants,
48                     ↪ _linksDataParts, _linksIndexParts, _header);
49                 _createExternalSourceTreeMethods = () => new
50                     ↪ UInt64ExternalLinksSourcesSizeBalancedTreeMethods(Constants,
51                     ↪ _linksDataParts, _linksIndexParts, _header);
52                 _createInternalTargetTreeMethods = () => new
53                     ↪ UInt64InternalLinksTargetsSizeBalancedTreeMethods(Constants,
54                     ↪ _linksDataParts, _linksIndexParts, _header);
55                 _createExternalTargetTreeMethods = () => new
56                     ↪ UInt64ExternalLinksTargetsSizeBalancedTreeMethods(Constants,
57                     ↪ _linksDataParts, _linksIndexParts, _header);
58             }
59             else
60             {
61                 _createInternalSourceTreeMethods = () => new
62                     ↪ UInt64InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
63                     ↪ _linksDataParts, _linksIndexParts, _header);
64                 _createExternalSourceTreeMethods = () => new
65                     ↪ UInt64ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
66                     ↪ _linksDataParts, _linksIndexParts, _header);
67                 _createInternalTargetTreeMethods = () => new
68                     ↪ UInt64InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(Constants,
69                     ↪ _linksDataParts, _linksIndexParts, _header);
70                 _createExternalTargetTreeMethods = () => new
71                     ↪ UInt64ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods(Constants,
72                     ↪ _linksDataParts, _linksIndexParts, _header);
73             }
74             Init(dataMemory, indexMemory);
75         }
76
77         [MethodImpl(MethodImplOptions.AggressiveInlining)]
78         protected override void SetPointers(IResizableDirectMemory dataMemory,
79             ↪ IResizableDirectMemory indexMemory)
80         {
81             _linksDataParts = (RawLinkDataPart<TLink>*)dataMemory.Pointer;
82         }
83     }
84 }

```



```

55     _linksIndexParts = (RawLinkIndexPart<TLink>*)indexMemory.Pointer;
56     _header = (LinksHeader<TLink>*)indexMemory.Pointer;
57     if (_useLinkedList)
58     {
59         InternalSourcesListMethods = new
60             ↳ UInt64InternalLinksSourcesLinkedListMethods(Constants, _linksDataParts,
61                 ↳ _linksIndexParts);
62     }
63     else
64     {
65         InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
66         ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
67         InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
68         ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
69         UnusedLinksListMethods = new UInt64UnusedLinksListMethods(_linksDataParts, _header);
70     }
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     protected override void ResetPointers()
73     {
74         base.ResetPointers();
75         _linksDataParts = null;
76         _linksIndexParts = null;
77         _header = null;
78     }
79
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
85         ↳ => ref _linksDataParts[linkIndex];
86
87     [MethodImpl(MethodImplOptions.AggressiveInlining)]
88     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
89         ↳ linkIndex) => ref _linksIndexParts[linkIndex];
90
91     [MethodImpl(MethodImplOptions.AggressiveInlining)]
92     protected override bool AreEqual(ulong first, ulong second) => first == second;
93
94     [MethodImpl(MethodImplOptions.AggressiveInlining)]
95     protected override bool LessThan(ulong first, ulong second) => first < second;
96
97     [MethodImpl(MethodImplOptions.AggressiveInlining)]
98     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
99
100    [MethodImpl(MethodImplOptions.AggressiveInlining)]
101    protected override bool GreaterThan(ulong first, ulong second) => first > second;
102
103    [MethodImpl(MethodImplOptions.AggressiveInlining)]
104    protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
105
106    [MethodImpl(MethodImplOptions.AggressiveInlining)]
107    protected override ulong GetZero() => 0UL;
108
109    [MethodImpl(MethodImplOptions.AggressiveInlining)]
110    protected override ulong GetOne() => 1UL;
111
112    [MethodImpl(MethodImplOptions.AggressiveInlining)]
113    protected override long ConvertToInt64(ulong value) => (long)value;
114
115    [MethodImpl(MethodImplOptions.AggressiveInlining)]
116    protected override ulong ConvertToAddress(long value) => (ulong)value;
117
118    [MethodImpl(MethodImplOptions.AggressiveInlining)]
119    protected override ulong Add(ulong first, ulong second) => first + second;
120
121    [MethodImpl(MethodImplOptions.AggressiveInlining)]
122    protected override ulong Subtract(ulong first, ulong second) => first - second;
123
124    [MethodImpl(MethodImplOptions.AggressiveInlining)]
125    protected override ulong Increment(ulong link) => ++link;
126
127    [MethodImpl(MethodImplOptions.AggressiveInlining)]
128    protected override ulong Decrement(ulong link) => --link;
129 }

```

1.78 ./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    }
30 }

```

1.79 ./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 }

```

```

42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
    ↪ rootSource, TLink rootTarget);
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
    ↪ rootSource, TLink rootTarget);
47
48 [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 FirstIsToTheLeftOfSecond(TLink first, TLink second)
63 {
64     ref var firstLink = ref GetLinkReference(first);
65     ref var secondLink = ref GetLinkReference(second);
66     return FirstIsToTheLeftOfSecond(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
126 [MethodImpl(MethodImplOptions.AggressiveInlining)]
127 protected bool IsChild(TLink parent, TLink possibleChild)
128 {
129     var parentSize = GetSize(parent);
130     var childSize = GetSizeOrZero(possibleChild);
131     return GreaterThanZero(childSize) && LessOrEqualThan(childSize, parentSize);
132 }
133
134 [MethodImpl(MethodImplOptions.AggressiveInlining)]
135 protected virtual sbyte GetBalanceValue(TLink storedValue)
136 {
137     unchecked
138     {
139         var value = _addressToInt32Converter.Convert(Bit<TLink>.PartialRead(storedValue,
140             ↪ 0, 3));
141         value |= 0xF8 * ((value & 4) >> 2); // if negative, then continue ones to the
142             ↪ end of sbyte
143         return (sbyte)value;
144     }
145 }
146
147 [MethodImpl(MethodImplOptions.AggressiveInlining)]
148 protected virtual void SetBalanceValue(ref TLink storedValue, sbyte value)
149 {
150     unchecked
151     {
152         var packagedValue = _int32ToAddressConverter.Convert((byte)value >> 5 & 4 |
153             ↪ value & 3);
154         var modified = Bit<TLink>.PartialWrite(storedValue, packagedValue, 0, 3);
155         storedValue = modified;
156     }
157 }
158
159 public TLink this[TLink index]
160 {
161     [MethodImpl(MethodImplOptions.AggressiveInlining)]
162     get
163     {
164         var root = GetTreeRoot();
165         if (GreaterOrEqualThan(index, GetSize(root)))
166         {
167             return Zero;
168         }
169         while (!EqualToZero(root))
170         {
171             var left = GetLeftOrDefault(root);
172             var leftSize = GetSizeOrZero(left);
173             if (LessThan(index, leftSize))
174             {
175                 root = left;
176                 continue;
177             }
178             if (AreEqual(index, leftSize))
179             {
180                 return root;
181             }
182             root = GetRightOrDefault(root);
183             index = Subtract(index, Increment(leftSize));
184         }
185         return Zero; // TODO: Impossible situation exception (only if tree structure
186             ↪ broken)
187     }
188 }

```

```

184
185 /// <summary>
186 /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
187   ↳ (концом).
188 /// </summary>
189 /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
190 /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
191 /// <returns>Индекс искомой связи.</returns>
192 [MethodImpl(MethodImplOptions.AggressiveInlining)]
193 public TLink Search(TLink source, TLink target)
194 {
195     var root = GetTreeRoot();
196     while (!EqualToZero(root))
197     {
198         ref var rootLink = ref GetLinkReference(root);
199         var rootSource = rootLink.Source;
200         var rootTarget = rootLink.Target;
201         if (FirstIsToTheLeftOfSecond(source, target, rootSource, rootTarget)) //
202             ↳ node.Key < root.Key
203         {
204             root = GetLeftOrDefault(root);
205         }
206         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
207             ↳ node.Key > root.Key
208         {
209             root = GetRightOrDefault(root);
210         }
211         else // node.Key == root.Key
212         {
213             return root;
214         }
215     }
216     return Zero;
217 }
218
219 // TODO: Return indices range instead of references count
220 [MethodImpl(MethodImplOptions.AggressiveInlining)]
221 public TLink CountUsages(TLink link)
222 {
223     var root = GetTreeRoot();
224     var total = GetSize(root);
225     var totalRightIgnore = Zero;
226     while (!EqualToZero(root))
227     {
228         var @base = GetBasePartValue(root);
229         if (LessOrEqualThan(@base, link))
230         {
231             root = GetRightOrDefault(root);
232         }
233         else
234         {
235             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
236             root = GetLeftOrDefault(root);
237         }
238     }
239     root = GetTreeRoot();
240     var totalLeftIgnore = Zero;
241     while (!EqualToZero(root))
242     {
243         var @base = GetBasePartValue(root);
244         if (GreaterOrEqualThan(@base, link))
245         {
246             root = GetLeftOrDefault(root);
247         }
248         else
249         {
250             totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
251             root = GetRightOrDefault(root);
252         }
253     }
254     return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
255 }
256
257 [MethodImpl(MethodImplOptions.AggressiveInlining)]
258 public TLink EachUsage(TLink link, Func<IList<TLink>, TLink> handler)
259 {
260     var root = GetTreeRoot();

```

```

259         if (EqualToZero(root))
260         {
261             return Continue;
262         }
263         TLink first = Zero, current = root;
264         while (!EqualToZero(current))
265         {
266             var @base = GetBasePartValue(current);
267             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 }

```

1.80 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksRecursionlessSizeBalancedTreeMethodsBase

```

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 LinksRecursionlessSizeBalancedTreeMethodsBase<TLink> :
14         ↪ RecursionlessSizeBalancedTreeMethods<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 LinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants,
26             ↪ byte* links, byte* header)

```

```

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

```

```

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

```



```

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

```

1.81 ./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 }

```

```

16
17     protected readonly TLink Break;
18     protected readonly TLink Continue;
19     protected readonly byte* Links;
20     protected readonly byte* Header;
21
22     [MethodImpl(MethodImplOptions.AggressiveInlining)]
23     protected LinksSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants, byte* links,
24     ↪ byte* header)
25     {
26         Links = links;
27         Header = header;
28         Break = constants.Break;
29         Continue = constants.Continue;
30     }
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     protected abstract TLink GetTreeRoot();
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected abstract TLink GetBasePartValue(TLink link);
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
40     ↪ rootSource, TLink rootTarget);
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
44     ↪ rootSource, TLink rootTarget);
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
48     ↪ AsRef<LinksHeader<TLink>>(Header);
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected virtual ref RawLink<TLink> GetLinkReference(TLink link) => ref
52     ↪ AsRef<RawLink<TLink>>(Links + (RawLink<TLink>.SizeInBytes *
53     ↪ _addressToInt64Converter.Convert(link)));
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
57     {
58         ref var link = ref GetLinkReference(linkIndex);
59         return new Link<TLink>(linkIndex, link.Source, link.Target);
60     }
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
64     {
65         ref var firstLink = ref GetLinkReference(first);
66         ref var secondLink = ref GetLinkReference(second);
67         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
68         ↪ secondLink.Source, secondLink.Target);
69     }
70
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
73     {
74         ref var firstLink = ref GetLinkReference(first);
75         ref var secondLink = ref GetLinkReference(second);
76         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
77         ↪ secondLink.Source, secondLink.Target);
78     }
79
80     public TLink this[TLink index]
81     {
82         [MethodImpl(MethodImplOptions.AggressiveInlining)]
83         get
84         {
85             var root = GetTreeRoot();
86             if (GreaterOrEqualThan(index, GetSize(root)))
87             {
88                 return Zero;
89             }
90             while (!EqualToZero(root))
91             {
92                 var left = GetLeftOrDefault(root);
93                 var leftSize = GetSizeOrZero(left);
94                 if (LessThan(index, leftSize))

```

```

87         {
88             root = left;
89             continue;
90         }
91         if (AreEqual(index, leftSize))
92         {
93             return root;
94         }
95         root = GetRightOrDefault(root);
96         index = Subtract(index, Increment(leftSize));
97     }
98     return Zero; // TODO: Impossible situation exception (only if tree structure
99     ↪ broken)
100 }
101
102 /// <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     }
166 }

```

```

161     }
162     else
163     {
164         totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
165         root = GetRightOrDefault(root);
166     }
167 }
168 return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
169 }
170
171 [MethodImpl(MethodImplOptions.AggressiveInlining)]
172 public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
173     ↳ EachUsageCore(@base, GetTreeRoot(), handler);
174
175 // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
176 ↳ low-level MSIL stack.
177 [MethodImpl(MethodImplOptions.AggressiveInlining)]
178 private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
179 {
180     var @continue = Continue;
181     if (EqualToZero(link))
182     {
183         return @continue;
184     }
185     var linkBasePart = GetBasePartValue(link);
186     var @break = Break;
187     if (GreaterThan(linkBasePart, @base))
188     {
189         if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
190         {
191             return @break;
192         }
193     }
194     else if (LessThan(linkBasePart, @base))
195     {
196         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
197         {
198             return @break;
199         }
200     }
201     else //if (linkBasePart == @base)
202     {
203         if (AreEqual(handler(GetLinkValues(link)), @break))
204         {
205             return @break;
206         }
207         if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
208         {
209             return @break;
210         }
211         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
212         {
213             return @break;
214         }
215     }
216     return @continue;
217 }
218
219 [MethodImpl(MethodImplOptions.AggressiveInlining)]
220 protected override void PrintNodeValue(TLink node, StringBuilder sb)
221 {
222     ref var link = ref GetLinkReference(node);
223     sb.Append(' ');
224     sb.Append(link.Source);
225     sb.Append(' - ');
226     sb.Append(' > ');
227     sb.Append(link.Target);
228 }

```

1.82 ./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> :
  ↳ LinksAvlBalancedTreeMethodsBase<TLink>
8 {
9     [MethodImpl(MethodImplOptions.AggressiveInlining)]
10    public LinksSourcesAvlBalancedTreeMethods(LinksConstants<TLink> constants, byte* links,
  ↳ byte* header) : base(constants, links, header) { }
11
12    [MethodImpl(MethodImplOptions.AggressiveInlining)]
13    protected override ref TLink GetLeftReference(TLink node) => ref
  ↳ GetLinkReference(node).LeftAsSource;
14
15    [MethodImpl(MethodImplOptions.AggressiveInlining)]
16    protected override ref TLink GetRightReference(TLink node) => ref
  ↳ GetLinkReference(node).RightAsSource;
17
18    [MethodImpl(MethodImplOptions.AggressiveInlining)]
19    protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsSource;
20
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) =>
  ↳ GetLinkReference(node).LeftAsSource = left;
26
27    [MethodImpl(MethodImplOptions.AggressiveInlining)]
28    protected override void SetRight(TLink node, TLink right) =>
  ↳ GetLinkReference(node).RightAsSource = right;
29
30    [MethodImpl(MethodImplOptions.AggressiveInlining)]
31    protected override TLink GetSize(TLink node) =>
  ↳ GetSizeValue(GetLinkReference(node).SizeAsSource);
32
33    [MethodImpl(MethodImplOptions.AggressiveInlining)]
34    protected override void SetSize(TLink node, TLink size) => SetSizeValue(ref
  ↳ GetLinkReference(node).SizeAsSource, size);
35
36    [MethodImpl(MethodImplOptions.AggressiveInlining)]
37    protected override bool GetLeftIsChild(TLink node) =>
  ↳ GetLeftIsChildValue(GetLinkReference(node).SizeAsSource);
38
39    [MethodImpl(MethodImplOptions.AggressiveInlining)]
40    protected override void SetLeftIsChild(TLink node, bool value) =>
  ↳ SetLeftIsChildValue(ref GetLinkReference(node).SizeAsSource, value);
41
42    [MethodImpl(MethodImplOptions.AggressiveInlining)]
43    protected override bool GetRightIsChild(TLink node) =>
  ↳ GetRightIsChildValue(GetLinkReference(node).SizeAsSource);
44
45    [MethodImpl(MethodImplOptions.AggressiveInlining)]
46    protected override void SetRightIsChild(TLink node, bool value) =>
  ↳ SetRightIsChildValue(ref GetLinkReference(node).SizeAsSource, value);
47
48    [MethodImpl(MethodImplOptions.AggressiveInlining)]
49    protected override sbyte GetBalance(TLink node) =>
  ↳ GetBalanceValue(GetLinkReference(node).SizeAsSource);
50
51    [MethodImpl(MethodImplOptions.AggressiveInlining)]
52    protected override void SetBalance(TLink node, sbyte value) => SetBalanceValue(ref
  ↳ GetLinkReference(node).SizeAsSource, value);
53
54    [MethodImpl(MethodImplOptions.AggressiveInlining)]
55    protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
56
57    [MethodImpl(MethodImplOptions.AggressiveInlining)]
58    protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Source;
59
60    [MethodImpl(MethodImplOptions.AggressiveInlining)]
61    protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
  ↳ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
  ↳ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
62
63    [MethodImpl(MethodImplOptions.AggressiveInlining)]
64    protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
  ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
  ↳ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
65
66    [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

67     protected override void ClearNode(TLink node)
68     {
69         ref var link = ref GetLinkReference(node);
70         link.LeftAsSource = Zero;
71         link.RightAsSource = Zero;
72         link.SizeAsSource = Zero;
73     }
74 }
75 }

```

1.83 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksSourcesRecursionlessSizeBalancedTreeMethods

```

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 LinksSourcesRecursionlessSizeBalancedTreeMethods<TLink> :
8      ↪ LinksRecursionlessSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink> constants,
12         ↪ byte* links, 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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsSource;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override void SetLeft(TLink node, TLink left) =>
30         ↪ GetLinkReference(node).LeftAsSource = left;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetRight(TLink node, TLink right) =>
34         ↪ GetLinkReference(node).RightAsSource = right;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsSource;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override void SetSize(TLink node, TLink size) =>
41         ↪ GetLinkReference(node).SizeAsSource = size;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Source;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
51         ↪ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
52         ↪ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
56         ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
57         ↪ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(TLink node)
61         {
62             ref var link = ref GetLinkReference(node);
63             link.LeftAsSource = Zero;
64             link.RightAsSource = Zero;
65             link.SizeAsSource = Zero;
66         }
67     }
68 }
69 }

```

1.84 ./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>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksSourcesSizeBalancedTreeMethods(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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsSource;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override void SetLeft(TLink node, TLink left) =>
30             ↳ GetLinkReference(node).LeftAsSource = left;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetRight(TLink node, TLink right) =>
34             ↳ GetLinkReference(node).RightAsSource = right;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsSource;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override void SetSize(TLink node, TLink size) =>
41             ↳ GetLinkReference(node).SizeAsSource = size;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Source;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
51             ↳ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
52             ↳ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
53
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
56             ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
57             ↳ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(TLink node)
61         {
62             ref var link = ref GetLinkReference(node);
63             link.LeftAsSource = Zero;
64             link.RightAsSource = Zero;
65             link.SizeAsSource = Zero;
66         }
67     }
68 }

```

1.85 ./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>

```

```

8 {
9     [MethodImpl(MethodImplOptions.AggressiveInlining)]
10    public LinksTargetsAvlBalancedTreeMethods(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).LeftAsTarget;
16
17    [MethodImpl(MethodImplOptions.AggressiveInlining)]
18    protected override ref TLink GetRightReference(TLink node) => ref
19        ↳ GetLinkReference(node).RightAsTarget;
20
21    [MethodImpl(MethodImplOptions.AggressiveInlining)]
22    protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsTarget;
23
24    [MethodImpl(MethodImplOptions.AggressiveInlining)]
25    protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsTarget;
26
27    [MethodImpl(MethodImplOptions.AggressiveInlining)]
28    protected override void SetLeft(TLink node, TLink left) =>
29        ↳ GetLinkReference(node).LeftAsTarget = left;
30
31    [MethodImpl(MethodImplOptions.AggressiveInlining)]
32    protected override void SetRight(TLink node, TLink right) =>
33        ↳ GetLinkReference(node).RightAsTarget = right;
34
35    [MethodImpl(MethodImplOptions.AggressiveInlining)]
36    protected override TLink GetSize(TLink node) =>
37        ↳ GetSizeValue(GetLinkReference(node).SizeAsTarget);
38
39    [MethodImpl(MethodImplOptions.AggressiveInlining)]
40    protected override void SetSize(TLink node, TLink size) => SetSizeValue(ref
41        ↳ GetLinkReference(node).SizeAsTarget, size);
42
43    [MethodImpl(MethodImplOptions.AggressiveInlining)]
44    protected override bool GetLeftIsChild(TLink node) =>
45        ↳ GetLeftIsChildValue(GetLinkReference(node).SizeAsTarget);
46
47    [MethodImpl(MethodImplOptions.AggressiveInlining)]
48    protected override void SetLeftIsChild(TLink node, bool value) =>
49        ↳ SetLeftIsChildValue(ref GetLinkReference(node).SizeAsTarget, value);
50
51    [MethodImpl(MethodImplOptions.AggressiveInlining)]
52    protected override bool GetRightIsChild(TLink node) =>
53        ↳ GetRightIsChildValue(GetLinkReference(node).SizeAsTarget);
54
55    [MethodImpl(MethodImplOptions.AggressiveInlining)]
56    protected override void SetRightIsChild(TLink node, bool value) =>
57        ↳ SetRightIsChildValue(ref GetLinkReference(node).SizeAsTarget, value);
58
59    [MethodImpl(MethodImplOptions.AggressiveInlining)]
60    protected override sbyte GetBalance(TLink node) =>
61        ↳ GetBalanceValue(GetLinkReference(node).SizeAsTarget);
62
63    [MethodImpl(MethodImplOptions.AggressiveInlining)]
64    protected override void SetBalance(TLink node, sbyte value) => SetBalanceValue(ref
65        ↳ GetLinkReference(node).SizeAsTarget, value);
66
67    [MethodImpl(MethodImplOptions.AggressiveInlining)]
68    protected override TLink GetTreeRoot() => GetHeaderReference().RootAsTarget;
69
70    [MethodImpl(MethodImplOptions.AggressiveInlining)]
71    protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Target;
72
73    [MethodImpl(MethodImplOptions.AggressiveInlining)]
74    protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
75        ↳ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
76        ↳ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
77
78    [MethodImpl(MethodImplOptions.AggressiveInlining)]
79    protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
80        ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
81        ↳ (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));
82
83    [MethodImpl(MethodImplOptions.AggressiveInlining)]
84    protected override void ClearNode(TLink node)
85    {

```



```

69         ref var link = ref GetLinkReference(node);
70         link.LeftAsTarget = Zero;
71         link.RightAsTarget = Zero;
72         link.SizeAsTarget = Zero;
73     }
74 }
75 }

```

1.86 ./csharp/Platform.Data.Doublets/Memory/United/Generic/LinksTargetsRecursionlessSizeBalancedTreeMethods

```

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 LinksTargetsRecursionlessSizeBalancedTreeMethods<TLink> :
8          ↳ LinksRecursionlessSizeBalancedTreeMethodsBase<TLink>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<TLink> constants,
12             ↳ byte* links, 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 }

```

1.87 ./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 }

```

1.88 ./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     }

```

1.89 ./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         }
76     }

```

```

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         return @break;
216     }
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             freeLink = header.AllocatedLinks = Increment(header.AllocatedLinks);
391             _memory.UsedCapacity += LinkSizeInBytes;
392         }
393         return freeLink;
394     }
395
396 [MethodImpl(MethodImplOptions.AggressiveInlining)]
397 public virtual void Delete(ICollection<TLink> restrictions)
398 {
399     ref var header = ref GetHeaderReference();
400     var link = restrictions[Constants.IndexPart];
401     if (LessThan(link, header.AllocatedLinks)
402     {
403         UnusedLinksListMethods.AttachAsFirst(link);
404     }
405     else if (AreEqual(link, header.AllocatedLinks)
406     {
407         header.AllocatedLinks = Decrement(header.AllocatedLinks);
408         _memory.UsedCapacity -= LinkSizeInBytes;
409         // Убираем все связи, находящиеся в списке свободных в конце файла, до тех пор,
410         ↳ пока не дойдём до первой существующей связи
411         // Позволяет оптимизировать количество выделенных связей (AllocatedLinks)
412         while (GreaterThan(header.AllocatedLinks, GetZero()) &&
413             ↳ IsUnusedLink(header.AllocatedLinks))
414         {
415             UnusedLinksListMethods.Detach(header.AllocatedLinks);
416             header.AllocatedLinks = Decrement(header.AllocatedLinks);
417             _memory.UsedCapacity -= LinkSizeInBytes;
418         }
419     }
420
421 [MethodImpl(MethodImplOptions.AggressiveInlining)]
422 public IList<TLink> GetLinkStruct(TLink linkIndex)
423 {
424     ref var link = ref GetLinkReference(linkIndex);
425     return new Link<TLink>(linkIndex, link.Source, link.Target);
426 }
427
428 /// <remarks>
429 /// TODO: Возможно это должно быть событием, вызываемым из IMemory, в том случае, если
430 ↳ адрес реально поменялся
431 ///
432 /// Указатель this.links может быть в том же месте,
433 /// так как 0-я связь не используется и имеет такой же размер как Header,
434 /// поэтому header размещается в том же месте, что и 0-я связь
435 /// </remarks>
436 [MethodImpl(MethodImplOptions.AggressiveInlining)]
437 protected abstract void SetPointers(IResizableDirectMemory memory);
438
439 [MethodImpl(MethodImplOptions.AggressiveInlining)]
440 protected virtual void ResetPointers()
441 {
442     SourcesTreeMethods = null;
443     TargetsTreeMethods = null;

```

```

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

```

```

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

```

1.90 ./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> :
11         ↳ AbsoluteCircularDoublyLinkedListMethods<TLink>, 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         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

52     protected override void SetPrevious(TLink element, TLink previous) =>
53         ↪ GetLinkReference(element).Source = previous;
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override void SetNext(TLink element, TLink next) =>
57         ↪ GetLinkReference(element).Target = next;
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     protected override void SetSize(TLink size) => GetHeaderReference().FreeLinks = size;
61 }
62 }

```

1.91 ./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 =
13             ↪ EqualityComparer<TLink>.Default;
14
15         public static readonly long SizeInBytes = Structure<RawLink<TLink>>.Size;
16
17         public TLink Source;
18         public TLink Target;
19         public TLink LeftAsSource;
20         public TLink RightAsSource;
21         public TLink SizeAsSource;
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 RawLink<TLink> link ? Equals(link) :
28             ↪ false;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public bool Equals(RawLink<TLink> other)
32             => _equalityComparer.Equals(Source, other.Source)
33             && _equalityComparer.Equals(Target, other.Target)
34             && _equalityComparer.Equals(LeftAsSource, other.LeftAsSource)
35             && _equalityComparer.Equals(RightAsSource, other.RightAsSource)
36             && _equalityComparer.Equals(SizeAsSource, other.SizeAsSource)
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() => (Source, Target, LeftAsSource, RightAsSource,
43             ↪ SizeAsSource, LeftAsTarget, RightAsTarget, SizeAsTarget).GetHashCode();
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public static bool operator ==(RawLink<TLink> left, RawLink<TLink> right) =>
47             ↪ left.Equals(right);
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         public static bool operator !=(RawLink<TLink> left, RawLink<TLink> right) => !(left ==
51             ↪ right);
52     }
53 }

```

1.92 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksRecursionlessSizeBalancedTreeMethods

```

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 UInt32LinksRecursionlessSizeBalancedTreeMethodsBase :
9         ↪ LinksRecursionlessSizeBalancedTreeMethodsBase<uint>
10     {
11         protected new readonly RawLink<uint>* Links;
12         protected new readonly LinksHeader<uint>* Header;

```

```

12     protected UInt32LinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<uint>
13     ↪ constants, RawLink<uint>* links, LinksHeader<uint>* header)
14         : base(constants, (byte*)links, (byte*)header)
15     {
16         Links = links;
17         Header = header;
18     }
19
20     [MethodImpl(MethodImplOptions.AggressiveInlining)]
21     protected override uint GetZero() => 0U;
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected override bool EqualToZero(uint value) => value == 0U;
25
26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     protected override bool AreEqual(uint first, uint second) => first == second;
28
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected override bool GreaterThanZero(uint value) => value > 0U;
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     protected override bool GreaterThan(uint first, uint second) => first > second;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override bool GreaterOrEqualThan(uint first, uint second) => first >= second;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override bool GreaterOrEqualThanZero(uint value) => true; // value >= 0 is
    ↪ always true for uint
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override bool LessOrEqualThanZero(uint value) => value == 0U; // value is
    ↪ always >= 0 for uint
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override bool LessOrEqualThan(uint first, uint second) => first <= second;
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override bool LessThanZero(uint value) => false; // value < 0 is always false
    ↪ for uint
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool LessThan(uint first, uint second) => first < second;
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     protected override uint Increment(uint value) => ++value;
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     protected override uint Decrement(uint value) => --value;
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     protected override uint Add(uint first, uint second) => first + second;
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     protected override uint Subtract(uint first, uint second) => first - second;
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override bool FirstIsToTheLeftOfSecond(uint first, uint 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(uint first, uint 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<uint> GetHeaderReference() => ref *Header;
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

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

```

1.93 ./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 :
9          ↳ LinksSizeBalancedTreeMethodsBase<uint>
10     {
11         protected new readonly RawLink<uint>* Links;
12         protected new readonly LinksHeader<uint>* Header;
13
14         protected UInt32LinksSizeBalancedTreeMethodsBase(LinksConstants<uint> constants,
15             ↳ RawLink<uint>* links, LinksHeader<uint>* header)
16             : base(constants, (byte*)links, (byte*)header)
17         {
18             Links = links;
19             Header = header;
20         }
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override uint GetZero() => 0U;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override bool EqualToZero(uint value) => value == 0U;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override bool AreEqual(uint first, uint second) => first == second;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override bool GreaterThanZero(uint value) => value > 0U;
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected override bool GreaterThan(uint first, uint second) => first > second;
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected override bool GreaterOrEqualThan(uint first, uint second) => first >= second;
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected override bool GreaterOrEqualThanZero(uint value) => true; // value >= 0 is
42             ↳ always true for uint
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         protected override bool LessOrEqualThanZero(uint value) => value == 0U; // value is
46             ↳ always >= 0 for uint
47
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         protected override bool LessOrEqualThan(uint first, uint second) => first <= second;
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override bool LessThanZero(uint value) => false; // value < 0 is always false
53             ↳ for uint
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override bool LessThan(uint first, uint second) => first < second;
57
58         [MethodImpl(MethodImplOptions.AggressiveInlining)]
59         protected override uint Increment(uint value) => ++value;
60
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         protected override uint Decrement(uint value) => --value;
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         protected override uint Add(uint first, uint second) => first + second;
66
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         protected override uint Subtract(uint first, uint second) => first - second;
69
70         [MethodImpl(MethodImplOptions.AggressiveInlining)]
71         protected override bool FirstIsToTheLeftOfSecond(uint first, uint second)
72         {
73             ref var firstLink = ref Links[first];
74             ref var secondLink = ref Links[second];
75         }
76     }
77 }

```

```

70         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
71             ↪ secondLink.Source, secondLink.Target);
72     }
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     protected override bool FirstIsToTheRightOfSecond(uint first, uint second)
75     {
76         ref var firstLink = ref Links[first];
77         ref var secondLink = ref Links[second];
78         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
79             ↪ secondLink.Source, secondLink.Target);
80     }
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     protected override ref LinksHeader<uint> GetHeaderReference() => ref *Header;
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     protected override ref RawLink<uint> GetLinkReference(uint link) => ref Links[link];
86 }
87 }

```

1.94 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksSourcesRecursionlessSizeBalancedTree

```

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 UInt32LinksSourcesRecursionlessSizeBalancedTreeMethods :
8         ↪ UInt32LinksRecursionlessSizeBalancedTreeMethodsBase
9     {
10         public UInt32LinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<uint>
11             ↪ constants, RawLink<uint>* links, LinksHeader<uint>* header) : base(constants, links,
12             ↪ 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     }
59 }

```

```

49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override void ClearNode(uint node)
51     {
52         ref var link = ref Links[node];
53         link.LeftAsSource = 0U;
54         link.RightAsSource = 0U;
55         link.SizeAsSource = 0U;
56     }
57 }
58 }

```

1.95 ./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         public UInt32LinksSourcesSizeBalancedTreeMethods(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].LeftAsSource;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected override ref uint GetRightReference(uint node) => ref
18             ↳ Links[node].RightAsSource;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override uint GetLeft(uint node) => Links[node].LeftAsSource;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override uint GetRight(uint node) => Links[node].RightAsSource;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override void SetLeft(uint node, uint left) => Links[node].LeftAsSource = left;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override void SetRight(uint node, uint right) => Links[node].RightAsSource =
31             ↳ right;
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         protected override uint GetSize(uint node) => Links[node].SizeAsSource;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override void SetSize(uint node, uint size) => Links[node].SizeAsSource = size;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override uint GetTreeRoot() => Header->RootAsSource;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override uint GetBasePartValue(uint link) => Links[link].Source;
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected override bool FirstIsToTheLeftOfSecond(uint firstSource, uint firstTarget,
47             ↳ uint secondSource, uint secondTarget)
48             => firstSource < secondSource || (firstSource == secondSource && firstTarget <
49                 ↳ secondTarget);
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override bool FirstIsToTheRightOfSecond(uint firstSource, uint firstTarget,
53             ↳ uint secondSource, uint secondTarget)
54             => firstSource > secondSource || (firstSource == secondSource && firstTarget >
55                 ↳ secondTarget);
56
57         [MethodImpl(MethodImplOptions.AggressiveInlining)]
58         protected override void ClearNode(uint node)
59         {
60             ref var link = ref Links[node];
61             link.LeftAsSource = 0U;
62             link.RightAsSource = 0U;
63             link.SizeAsSource = 0U;
64         }
65     }
66 }

```


1.96 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksTargetsRecursionlessSizeBalancedTreeMethods.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 UInt32LinksTargetsRecursionlessSizeBalancedTreeMethods :
8         ↳ UInt32LinksRecursionlessSizeBalancedTreeMethodsBase
9     {
10
11         public UInt32LinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<uint>
12             ↳ constants, RawLink<uint>* links, LinksHeader<uint>* header) : base(constants, links,
13             ↳ header) { }
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         protected override ref uint GetLeftReference(uint node) => ref Links[node].LeftAsTarget;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref uint GetRightReference(uint node) => ref
20             ↳ Links[node].RightAsTarget;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override uint GetLeft(uint node) => Links[node].LeftAsTarget;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override uint GetRight(uint node) => Links[node].RightAsTarget;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override void SetLeft(uint node, uint left) => Links[node].LeftAsTarget = left;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override void SetRight(uint node, uint right) => Links[node].RightAsTarget =
33             ↳ right;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override uint GetSize(uint node) => Links[node].SizeAsTarget;
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         protected override void SetSize(uint node, uint size) => Links[node].SizeAsTarget = size;
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         protected override uint GetTreeRoot() => Header->RootAsTarget;
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         protected override uint GetBasePartValue(uint link) => Links[link].Target;
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override bool FirstIsToTheLeftOfSecond(uint firstSource, uint firstTarget,
49             ↳ uint secondSource, uint secondTarget)
50             => firstTarget < secondTarget || (firstTarget == secondTarget && firstSource <
51             ↳ secondSource);
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override bool FirstIsToTheRightOfSecond(uint firstSource, uint firstTarget,
55             ↳ uint secondSource, uint secondTarget)
56             => firstTarget > secondTarget || (firstTarget == secondTarget && firstSource >
57             ↳ secondSource);
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(uint node)
61         {
62             ref var link = ref Links[node];
63             link.LeftAsTarget = 0U;
64             link.RightAsTarget = 0U;
65             link.SizeAsTarget = 0U;
66         }
67     }
68 }
```

1.97 ./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
11     }
```

```

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

```

1.98 ./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>
17     /// </summary>
18     public unsafe class UInt32UnitedMemoryLinks : UnitedMemoryLinksBase<uint>
19     {
20         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     if (indexTreeType == IndexTreeType.SizeBalancedTree)
52     {
53         _createSourceTreeMethods = () => new
54           ↳ UInt32LinksSourcesSizeBalancedTreeMethods(Constants, _links, _header);
55         _createTargetTreeMethods = () => new
56           ↳ UInt32LinksTargetsSizeBalancedTreeMethods(Constants, _links, _header);
57     }
58     else
59     {
60         _createSourceTreeMethods = () => new
61           ↳ UInt32LinksSourcesRecursionlessSizeBalancedTreeMethods(Constants, _links,
62           ↳ _header);
63         _createTargetTreeMethods = () => new
64           ↳ UInt32LinksTargetsRecursionlessSizeBalancedTreeMethods(Constants, _links,
65           ↳ _header);
66     }
67     Init(memory, memoryReservationStep);
68 }
69
70 [MethodImpl(MethodImplOptions.AggressiveInlining)]
71 protected override void SetPointers(IResizableDirectMemory memory)
72 {
73     _header = (LinksHeader<uint>*)memory.Pointer;
74     _links = (RawLink<uint>*)memory.Pointer;
75     SourcesTreeMethods = _createSourceTreeMethods();
76     TargetsTreeMethods = _createTargetTreeMethods();
77     UnusedLinksListMethods = new UInt32UnusedLinksListMethods(_links, _header);
78 }
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 protected override void ResetPointers()
82 {
83     base.ResetPointers();
84     _links = null;
85     _header = null;
86 }
87
88 [MethodImpl(MethodImplOptions.AggressiveInlining)]
89 protected override ref LinksHeader<uint> GetHeaderReference() => ref *_header;
90
91 [MethodImpl(MethodImplOptions.AggressiveInlining)]
92 protected override ref RawLink<uint> GetLinkReference(uint linkIndex) => ref
93   ↳ _links[linkIndex];
94
95 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

80     protected override bool AreEqual(uint first, uint second) => first == second;
81
82     [MethodImpl(MethodImplOptions.AggressiveInlining)]
83     protected override bool LessThan(uint first, uint second) => first < second;
84
85     [MethodImpl(MethodImplOptions.AggressiveInlining)]
86     protected override bool LessOrEqualThan(uint first, uint second) => first <= second;
87
88     [MethodImpl(MethodImplOptions.AggressiveInlining)]
89     protected override bool GreaterThan(uint first, uint second) => first > second;
90
91     [MethodImpl(MethodImplOptions.AggressiveInlining)]
92     protected override bool GreaterOrEqualThan(uint first, uint second) => first >= second;
93
94     [MethodImpl(MethodImplOptions.AggressiveInlining)]
95     protected override uint GetZero() => 0U;
96
97     [MethodImpl(MethodImplOptions.AggressiveInlining)]
98     protected override uint GetOne() => 1U;
99
100    [MethodImpl(MethodImplOptions.AggressiveInlining)]
101    protected override long ConvertToInt64(uint value) => (long)value;
102
103    [MethodImpl(MethodImplOptions.AggressiveInlining)]
104    protected override uint ConvertToAddress(long value) => (uint)value;
105
106    [MethodImpl(MethodImplOptions.AggressiveInlining)]
107    protected override uint Add(uint first, uint second) => first + second;
108
109    [MethodImpl(MethodImplOptions.AggressiveInlining)]
110    protected override uint Subtract(uint first, uint second) => first - second;
111
112    [MethodImpl(MethodImplOptions.AggressiveInlining)]
113    protected override uint Increment(uint link) => ++link;
114
115    [MethodImpl(MethodImplOptions.AggressiveInlining)]
116    protected override uint Decrement(uint link) => --link;
117 }
118 }

```

1.99 ./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 }

```

1.100 ./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>

```

```

10 {
11     protected new readonly RawLink<ulong>* Links;
12     protected new readonly LinksHeader<ulong>* Header;
13
14     protected UInt64LinksAvlBalancedTreeMethodsBase(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)]
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
53     ↳ for ulong
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override bool LessThan(ulong first, ulong second) => first < second;
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     protected override ulong Increment(ulong value) => ++value;
60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     protected override ulong Decrement(ulong value) => --value;
63
64     [MethodImpl(MethodImplOptions.AggressiveInlining)]
65     protected override ulong Add(ulong first, ulong second) => first + second;
66
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     protected override ulong Subtract(ulong first, ulong second) => first - second;
69
70     [MethodImpl(MethodImplOptions.AggressiveInlining)]
71     protected override bool FirstIsToTheLeftOfSecond(ulong first, ulong second)
72     {
73         ref var firstLink = ref Links[first];
74         ref var secondLink = ref Links[second];
75         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
76             ↳ secondLink.Source, secondLink.Target);
77     }
78
79     [MethodImpl(MethodImplOptions.AggressiveInlining)]
80     protected override bool FirstIsToTheRightOfSecond(ulong first, ulong second)
81     {
82         ref var firstLink = ref Links[first];
83         ref var secondLink = ref Links[second];
84         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
85             ↳ secondLink.Source, secondLink.Target);
86     }
87
88     [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 =
87         ↪ storedValue & 31UL | (size & 134217727UL) << 5;
88
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     protected override bool GetLeftIsChildValue(ulong value) => (value & 16UL) >> 4 == 1UL;
91
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     protected override void SetLeftIsChildValue(ref ulong storedValue, bool value) =>
94         ↪ storedValue = storedValue & 4294967279UL | (As<bool, byte>(ref value) & 1UL) << 4;
95
96     [MethodImpl(MethodImplOptions.AggressiveInlining)]
97     protected override bool GetRightIsChildValue(ulong value) => (value & 8UL) >> 3 == 1UL;
98
99     [MethodImpl(MethodImplOptions.AggressiveInlining)]
100    protected override void SetRightIsChildValue(ref ulong storedValue, bool value) =>
101        ↪ storedValue = storedValue & 4294967287UL | (As<bool, byte>(ref value) & 1UL) << 3;
102
103    [MethodImpl(MethodImplOptions.AggressiveInlining)]
104    protected override sbyte GetBalanceValue(ulong value) => unchecked((sbyte)(value & 7UL |
105        ↪ 0xF8UL * ((value & 4UL) >> 2))); // if negative, then continue ones to the end of
106        ↪ sbyte
107
108    [MethodImpl(MethodImplOptions.AggressiveInlining)]
109    protected override void SetBalanceValue(ref ulong storedValue, sbyte value) =>
110        ↪ storedValue = unchecked(storedValue & 4294967288UL | (ulong)((byte)value >> 5 & 4 |
111        ↪ value & 3) & 7UL);
112
113    [MethodImpl(MethodImplOptions.AggressiveInlining)]
114    protected override ref LinksHeader<ulong> GetHeaderReference() => ref *Header;
115
116    [MethodImpl(MethodImplOptions.AggressiveInlining)]
117    protected override ref RawLink<ulong> GetLinkReference(ulong link) => ref Links[link];
118 }

```

1.101 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksRecursionlessSizeBalancedTreeMeth

```

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 UInt64LinksRecursionlessSizeBalancedTreeMethodsBase :
9          ↪ LinksRecursionlessSizeBalancedTreeMethodsBase<ulong>
10     {
11         protected new readonly RawLink<ulong>* Links;
12         protected new readonly LinksHeader<ulong>* Header;
13
14         protected UInt64LinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<ulong>
15             ↪ constants, 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)]

```

```

39     protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
    ↪ always true for ulong
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
    ↪ always >= 0 for ulong
43
44     [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 }

```

1.102 ./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 :
    ↪ LinksSizeBalancedTreeMethodsBase<ulong>
9      {
10         protected new readonly RawLink<ulong>* Links;
11         protected new readonly LinksHeader<ulong>* Header;
12
13         protected UInt64LinksSizeBalancedTreeMethodsBase(LinksConstants<ulong> constants,
    ↪ RawLink<ulong>* links, LinksHeader<ulong>* header)
14             : base(constants, (byte*)links, (byte*)header)
15         {
16             Links = links;
17             Header = header;
18         }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override ulong GetZero() => 0UL;

```

```

22     [MethodImpl(MethodImplOptions.AggressiveInlining)]
23     protected override bool EqualToZero(ulong value) => value == 0UL;
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     protected override bool AreEqual(ulong first, ulong second) => first == second;
27
28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override bool GreaterThanZero(ulong value) => value > 0UL;
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override bool GreaterThan(ulong first, ulong second) => first > second;
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
39     ↪ always true for ulong
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
43     ↪ 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
50     ↪ for ulong
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected override bool LessThan(ulong first, ulong second) => first < second;
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override ulong Increment(ulong value) => ++value;
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     protected override ulong Decrement(ulong value) => --value;
60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     protected override ulong Add(ulong first, ulong second) => first + second;
63
64     [MethodImpl(MethodImplOptions.AggressiveInlining)]
65     protected override ulong Subtract(ulong first, ulong second) => first - second;
66
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     protected override bool FirstIsToTheLeftOfSecond(ulong first, ulong second)
69     {
70         ref var firstLink = ref Links[first];
71         ref var secondLink = ref Links[second];
72         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
73         ↪ secondLink.Source, secondLink.Target);
74     }
75
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     protected override bool FirstIsToTheRightOfSecond(ulong first, ulong second)
78     {
79         ref var firstLink = ref Links[first];
80         ref var secondLink = ref Links[second];
81         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
82         ↪ secondLink.Source, secondLink.Target);
83     }
84
85     [MethodImpl(MethodImplOptions.AggressiveInlining)]
86     protected override ref LinksHeader<ulong> GetHeaderReference() => ref *Header;
87
88     [MethodImpl(MethodImplOptions.AggressiveInlining)]
89     protected override ref RawLink<ulong> GetLinkReference(ulong link) => ref Links[link];
90 }

```

1.103 ./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 :
8     ↳ UInt64LinksAvlBalancedTreeMethodsBase
9 {
10     public UInt64LinksSourcesAvlBalancedTreeMethods(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].LeftAsSource;
17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     protected override ref ulong GetRightReference(ulong node) => ref
20         ↳ Links[node].RightAsSource;
21
22     [MethodImpl(MethodImplOptions.AggressiveInlining)]
23     protected override ulong GetLeft(ulong node) => Links[node].LeftAsSource;
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     protected override ulong GetRight(ulong node) => Links[node].RightAsSource;
27
28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsSource =
30         ↳ left;
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     protected override void SetRight(ulong node, ulong right) => Links[node].RightAsSource =
34         ↳ right;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override ulong GetSize(ulong node) => GetSizeValue(Links[node].SizeAsSource);
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override void SetSize(ulong node, ulong size) => SetSizeValue(ref
41         ↳ Links[node].SizeAsSource, size);
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override bool GetLeftIsChild(ulong node) =>
45         ↳ GetLeftIsChildValue(Links[node].SizeAsSource);
46
47     // [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     // protected override bool GetLeftIsChild(ulong node) => IsChild(node, GetLeft(node));
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override void SetLeftIsChild(ulong node, bool value) =>
52         ↳ SetLeftIsChildValue(ref Links[node].SizeAsSource, value);
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override bool GetRightIsChild(ulong node) =>
56         ↳ GetRightIsChildValue(Links[node].SizeAsSource);
57
58     // [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     // protected override bool GetRightIsChild(ulong node) => IsChild(node, GetRight(node));
60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     protected override void SetRightIsChild(ulong node, bool value) =>
63         ↳ SetRightIsChildValue(ref Links[node].SizeAsSource, value);
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override sbyte GetBalance(ulong node) =>
67         ↳ GetBalanceValue(Links[node].SizeAsSource);
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override void SetBalance(ulong node, sbyte value) => SetBalanceValue(ref
71         ↳ Links[node].SizeAsSource, value);
72
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     protected override ulong GetTreeRoot() => Header->RootAsSource;
75
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     protected override ulong GetBasePartValue(ulong link) => Links[link].Source;
78
79     [MethodImpl(MethodImplOptions.AggressiveInlining)]
80     protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
81         ↳ ulong secondSource, ulong secondTarget)
82         ↳ => firstSource < secondSource || (firstSource == secondSource && firstTarget <
83             ↳ secondTarget);
84
85
86

```

```

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 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 UInt64LinksSourcesRecursionlessSizeBalancedTreeMethods :
8         ↳ UInt64LinksRecursionlessSizeBalancedTreeMethodsBase
9     {
10         public UInt64LinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<ulong>
11             ↳ constants, RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants,
12             ↳ links, header) { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref ulong GetLeftReference(ulong node) => ref
16             ↳ Links[node].LeftAsSource;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref ulong GetRightReference(ulong node) => ref
20             ↳ Links[node].RightAsSource;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ulong GetLeft(ulong node) => Links[node].LeftAsSource;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override ulong GetRight(ulong node) => Links[node].RightAsSource;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsSource =
30             ↳ left;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetRight(ulong node, ulong right) => Links[node].RightAsSource =
34             ↳ right;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override ulong GetSize(ulong node) => Links[node].SizeAsSource;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override void SetSize(ulong node, ulong size) => Links[node].SizeAsSource =
41             ↳ size;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override ulong GetTreeRoot() => Header->RootAsSource;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override ulong GetBasePartValue(ulong link) => Links[link].Source;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
51             ↳ ulong secondSource, ulong secondTarget)
52             => firstSource < secondSource || (firstSource == secondSource && firstTarget <
53             ↳ secondTarget);
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
57             ↳ ulong secondSource, ulong secondTarget)
58             => firstSource > secondSource || (firstSource == secondSource && firstTarget >
59             ↳ secondTarget);
60
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

50     protected override void ClearNode(ulong node)
51     {
52         ref var link = ref Links[node];
53         link.LeftAsSource = OUL;
54         link.RightAsSource = OUL;
55         link.SizeAsSource = OUL;
56     }
57 }
58 }

```

1.105 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSourcesSizeBalancedTreeMethods.c

```

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 :
8          ↳ UInt64LinksSizeBalancedTreeMethodsBase
9      {
10         public UInt64LinksSourcesSizeBalancedTreeMethods(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].LeftAsSource;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref ulong GetRightReference(ulong node) => ref
20             ↳ Links[node].RightAsSource;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ulong GetLeft(ulong node) => Links[node].LeftAsSource;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override ulong GetRight(ulong node) => Links[node].RightAsSource;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsSource =
30             ↳ left;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetRight(ulong node, ulong right) => Links[node].RightAsSource =
34             ↳ right;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override ulong GetSize(ulong node) => Links[node].SizeAsSource;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override void SetSize(ulong node, ulong size) => Links[node].SizeAsSource =
41             ↳ size;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         protected override ulong GetTreeRoot() => Header->RootAsSource;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override ulong GetBasePartValue(ulong link) => Links[link].Source;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
51             ↳ ulong secondSource, ulong secondTarget)
52             ↳ => firstSource < secondSource || (firstSource == secondSource && firstTarget <
53                 ↳ secondTarget);
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
57             ↳ ulong secondSource, ulong secondTarget)
58             ↳ => firstSource > secondSource || (firstSource == secondSource && firstTarget >
59                 ↳ secondTarget);
60
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         protected override void ClearNode(ulong node)
63         {
64             ref var link = ref Links[node];
65             link.LeftAsSource = OUL;
66             link.RightAsSource = OUL;
67             link.SizeAsSource = OUL;
68         }
69     }
70 }

```

```
57     }  
58 }
```

1.106 ./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  
11         public UInt64LinksTargetsAvlBalancedTreeMethods(LinksConstants<ulong> constants,  
12             ↳ RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants, links, header)  
13             ↳ { }  
14  
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
16         protected override ref ulong GetLeftReference(ulong node) => ref  
17             ↳ Links[node].LeftAsTarget;  
18  
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
20         protected override ref ulong GetRightReference(ulong node) => ref  
21             ↳ Links[node].RightAsTarget;  
22  
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
24         protected override ulong GetLeft(ulong node) => Links[node].LeftAsTarget;  
25  
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
27         protected override ulong GetRight(ulong node) => Links[node].RightAsTarget;  
28  
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
30         protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsTarget =  
31             ↳ left;  
32  
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
34         protected override void SetRight(ulong node, ulong right) => Links[node].RightAsTarget =  
35             ↳ right;  
36  
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
38         protected override ulong GetSize(ulong node) => GetSizeValue(Links[node].SizeAsTarget);  
39  
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
41         protected override void SetSize(ulong node, ulong size) => SetSizeValue(ref  
42             ↳ Links[node].SizeAsTarget, size);  
43  
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
45         protected override bool GetLeftIsChild(ulong node) =>  
46             ↳ GetLeftIsChildValue(Links[node].SizeAsTarget);  
47  
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
49         protected override void SetLeftIsChild(ulong node, bool value) =>  
50             ↳ SetLeftIsChildValue(ref Links[node].SizeAsTarget, value);  
51  
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
53         protected override bool GetRightIsChild(ulong node) =>  
54             ↳ GetRightIsChildValue(Links[node].SizeAsTarget);  
55  
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
57         protected override void SetRightIsChild(ulong node, bool value) =>  
58             ↳ SetRightIsChildValue(ref Links[node].SizeAsTarget, value);  
59  
60         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
61         protected override sbyte GetBalance(ulong node) =>  
62             ↳ GetBalanceValue(Links[node].SizeAsTarget);  
63  
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
65         protected override void SetBalance(ulong node, sbyte value) => SetBalanceValue(ref  
66             ↳ Links[node].SizeAsTarget, value);  
67  
68         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
69         protected override ulong GetTreeRoot() => Header->RootAsTarget;  
70  
71         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
72         protected override ulong GetBasePartValue(ulong link) => Links[link].Target;  
73  
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]  
75         protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,  
76             ↳ ulong secondSource, ulong secondTarget)
```

```

61         => firstTarget < secondTarget || (firstTarget == secondTarget && firstSource <
        ↪ secondSource);
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
        ↪ ulong secondSource, ulong secondTarget)
65         => firstTarget > secondTarget || (firstTarget == secondTarget && firstSource >
        ↪ secondSource);
66
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     protected override void ClearNode(ulong node)
69     {
70         ref var link = ref Links[node];
71         link.LeftAsTarget = OUL;
72         link.RightAsTarget = OUL;
73         link.SizeAsTarget = OUL;
74     }
75 }
76 }

```

1.107 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksTargetsRecursionlessSizeBalancedTreeMethods

```

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 UInt64LinksTargetsRecursionlessSizeBalancedTreeMethods :
        ↪ UInt64LinksRecursionlessSizeBalancedTreeMethodsBase
8      {
9          public UInt64LinksTargetsRecursionlessSizeBalancedTreeMethods(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].LeftAsTarget;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref ulong GetRightReference(ulong node) => ref
        ↪ Links[node].RightAsTarget;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ulong GetLeft(ulong node) => Links[node].LeftAsTarget;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override ulong GetRight(ulong node) => Links[node].RightAsTarget;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsTarget =
        ↪ left;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override void SetRight(ulong node, ulong right) => Links[node].RightAsTarget =
        ↪ right;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override ulong GetSize(ulong node) => Links[node].SizeAsTarget;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected override void SetSize(ulong node, ulong size) => Links[node].SizeAsTarget =
        ↪ size;
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected override ulong GetTreeRoot() => Header->RootAsTarget;
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         protected override ulong GetBasePartValue(ulong link) => Links[link].Target;
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
        ↪ ulong secondSource, ulong secondTarget)
43             => firstTarget < secondTarget || (firstTarget == secondTarget && firstSource <
        ↪ secondSource);
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
        ↪ ulong secondSource, ulong secondTarget)

```

```

47         => firstTarget > secondTarget || (firstTarget == secondTarget && firstSource >
48             ↪ secondSource);
49
50 [MethodImpl(MethodImplOptions.AggressiveInlining)]
51 protected override void ClearNode(ulong node)
52 {
53     ref var link = ref Links[node];
54     link.LeftAsTarget = OUL;
55     link.RightAsTarget = OUL;
56     link.SizeAsTarget = OUL;
57 }
58 }

```

1.108 ./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];

```

```

53         link.LeftAsTarget = OUL;
54         link.RightAsTarget = OUL;
55         link.SizeAsTarget = OUL;
56     }
57 }
58 }

```

1.109 ./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.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="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         /// Создает 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 if (indexTreeType == IndexTreeType.SizeBalancedTree)
63             {
64                 _createSourceTreeMethods = () => new
65                     UInt64LinksSourcesSizeBalancedTreeMethods(Constants, _links, _header);
66                 _createTargetTreeMethods = () => new
67                     UInt64LinksTargetsSizeBalancedTreeMethods(Constants, _links, _header);
68             }
69             else
70             {
71

```

```

54         _createSourceTreeMethods = () => new
           ↳ UInt64LinksSourcesRecursionlessSizeBalancedTreeMethods(Constants, _links,
           ↳ _header);
55         _createTargetTreeMethods = () => new
           ↳ UInt64LinksTargetsRecursionlessSizeBalancedTreeMethods(Constants, _links,
           ↳ _header);
56     }
57     Init(memory, memoryReservationStep);
58 }
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected override void SetPointers(IResizableDirectMemory memory)
62 {
63     _header = (LinksHeader<ulong>*)memory.Pointer;
64     _links = (RawLink<ulong>*)memory.Pointer;
65     SourcesTreeMethods = _createSourceTreeMethods();
66     TargetsTreeMethods = _createTargetTreeMethods();
67     UnusedLinksListMethods = new UInt64UnusedLinksListMethods(_links, _header);
68 }
69
70 [MethodImpl(MethodImplOptions.AggressiveInlining)]
71 protected override void ResetPointers()
72 {
73     base.ResetPointers();
74     _links = null;
75     _header = null;
76 }
77
78 [MethodImpl(MethodImplOptions.AggressiveInlining)]
79 protected override ref LinksHeader<ulong> GetHeaderReference() => ref *_header;
80
81 [MethodImpl(MethodImplOptions.AggressiveInlining)]
82 protected override ref RawLink<ulong> GetLinkReference(ulong linkIndex) => ref
   ↳ _links[linkIndex];
83
84 [MethodImpl(MethodImplOptions.AggressiveInlining)]
85 protected override bool AreEqual(ulong first, ulong second) => first == second;
86
87 [MethodImpl(MethodImplOptions.AggressiveInlining)]
88 protected override bool LessThan(ulong first, ulong second) => first < second;
89
90 [MethodImpl(MethodImplOptions.AggressiveInlining)]
91 protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
92
93 [MethodImpl(MethodImplOptions.AggressiveInlining)]
94 protected override bool GreaterThan(ulong first, ulong second) => first > second;
95
96 [MethodImpl(MethodImplOptions.AggressiveInlining)]
97 protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
98
99 [MethodImpl(MethodImplOptions.AggressiveInlining)]
100 protected override ulong GetZero() => 0UL;
101
102 [MethodImpl(MethodImplOptions.AggressiveInlining)]
103 protected override ulong GetOne() => 1UL;
104
105 [MethodImpl(MethodImplOptions.AggressiveInlining)]
106 protected override long ConvertToInt64(ulong value) => (long)value;
107
108 [MethodImpl(MethodImplOptions.AggressiveInlining)]
109 protected override ulong ConvertToAddress(long value) => (ulong)value;
110
111 [MethodImpl(MethodImplOptions.AggressiveInlining)]
112 protected override ulong Add(ulong first, ulong second) => first + second;
113
114 [MethodImpl(MethodImplOptions.AggressiveInlining)]
115 protected override ulong Subtract(ulong first, ulong second) => first - second;
116
117 [MethodImpl(MethodImplOptions.AggressiveInlining)]
118 protected override ulong Increment(ulong link) => ++link;
119
120 [MethodImpl(MethodImplOptions.AggressiveInlining)]
121 protected override ulong Decrement(ulong link) => --link;
122 }
123 }

```

1.110 ./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 }

```

1.111 ./csharp/Platform.Data.Doublets/Numbers/Raw/LongRawNumberSequenceToNumberConverter.cs

```

1 using System.Runtime.CompilerServices;
2 using Platform.Collections.Stacks;
3 using Platform.Converters;
4 using Platform.Numbers;
5 using Platform.Reflection;
6 using Platform.Data.Doublets.Decorators;
7 using Platform.Data.Doublets.Sequences.Walkers;
8
9 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
10
11 namespace Platform.Data.Doublets.Numbers.Raw
12 {
13     public class LongRawNumberSequenceToNumberConverter<TSource, TTarget> :
14         ↳ LinksDecoratorBase<TSource>, IConverter<TSource, TTarget>
15     {
16         private static readonly int _bitsPerRawNumber = NumericType<TSource>.BitsSize - 1;
17         private static readonly uncheckedConverter<TSource, TTarget> _sourceToTargetConverter =
18             ↳ uncheckedConverter<TSource, TTarget>.Default;
19
20         private readonly IConverter<TSource> _numberToAddressConverter;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public LongRawNumberSequenceToNumberConverter(ILinks<TSource> links, IConverter<TSource>
24             ↳ numberToAddressConverter) : base(links) => _numberToAddressConverter =
25             ↳ numberToAddressConverter;
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         public TTarget Convert(TSource source)
29         {
30             var constants = Links.Constants;
31             var externalReferencesRange = constants.ExternalReferencesRange;
32             if (externalReferencesRange.HasValue &&
33                 ↳ externalReferencesRange.Value.Contains(source))
34             {
35                 return
36                     ↳ _sourceToTargetConverter.Convert(_numberToAddressConverter.Convert(source));
37             }
38             else
39             {
40                 var pair = Links.GetLink(source);
41                 var walker = new LeftSequenceWalker<TSource>(Links, new DefaultStack<TSource>(),
42                     ↳ (link) => externalReferencesRange.HasValue &&
43                     ↳ externalReferencesRange.Value.Contains(link));
44                 TTarget result = default;
45                 foreach (var element in walker.Walk(source))
46                 {
47                     result = Bit.Or(Bit.ShiftLeft(result, _bitsPerRawNumber), Convert(element));
48                 }
49                 return result;
50             }
51         }
52     }
53 }

```

1.112 ./csharp/Platform.Data.Doublets/Numbers/Row/NumberToLongRawNumberSequenceConverter.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Converters;
4  using Platform.Numbers;
5  using Platform.Reflection;
6  using Platform.Data.Doublets.Decorators;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Numbers.Row
11 {
12     public class NumberToLongRawNumberSequenceConverter<TSource, TTarget> :
13         ↳ LinksDecoratorBase<TTarget>, IConverter<TSource, TTarget>
14     {
15         private static readonly Comparer<TSource> _comparer = Comparer<TSource>.Default;
16         private static readonly TSource _maximumValue = NumericType<TSource>.MaxValue;
17         private static readonly int _bitsPerRawNumber = NumericType<TTarget>.BitsSize - 1;
18         private static readonly TSource _bitMask = Bit.ShiftRight(_maximumValue,
19             ↳ NumericType<TTarget>.BitsSize + 1);
20         private static readonly TSource _maximumConvertibleAddress = CheckedConverter<TTarget,
21             ↳ TSource>.Default.Convert(Arithmetic.Decrement(Hybrid<TTarget>.ExternalZero));
22         private static readonly UncheckedConverter<TSource, TTarget> _sourceToTargetConverter =
23             ↳ UncheckedConverter<TSource, TTarget>.Default;
24
25         private readonly IConverter<TTarget> _addressToNumberConverter;
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         public NumberToLongRawNumberSequenceConverter(ILinks<TTarget> links, IConverter<TTarget>
29             ↳ addressToNumberConverter) : base(links) => _addressToNumberConverter =
30             ↳ addressToNumberConverter;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public TTarget Convert(TSource source)
34         {
35             if (_comparer.Compare(source, _maximumConvertibleAddress) > 0)
36             {
37                 var numberPart = Bit.And(source, _bitMask);
38                 var convertedNumber = _addressToNumberConverter.Convert(_sourceToTargetConverter
39                     ↳ .Convert(numberPart));
40                 return Links.GetOrCreate(convertedNumber, Convert(Bit.ShiftRight(source,
41                     ↳ _bitsPerRawNumber)));
42             }
43             else
44             {
45                 return
46                     ↳ _addressToNumberConverter.Convert(_sourceToTargetConverter.Convert(source));
47             }
48         }
49     }
50 }

```

1.113 ./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)

```

```

24     {
25         var links = _links;
26         var nullConstant = links.Constants.Null;
27         var target = nullConstant;
28         for (var i = 0; !_equalityComparer.Equals(number, _zero) && i <
29             ↪ NumericType<TLink>.BitsSize; i++)
30         {
31             if (_equalityComparer.Equals(Bit.And(number, _one), _one))
32             {
33                 target = _equalityComparer.Equals(target, nullConstant)
34                     ? _powerOf2ToUnaryNumberConverter.Convert(i)
35                     : links.GetOrCreate(_powerOf2ToUnaryNumberConverter.Convert(i), target);
36             }
37             number = Bit.ShiftRight(number, 1);
38         }
39         return target;
40     }
41 }

```

1.114 ./csharp/Platform.Data.Doublets/Numbers/Unary/LinkToItsFrequencyNumberConverter.cs

```

1  using System;
2  using System.Collections.Generic;
3  using Platform.Interfaces;
4  using Platform.Converters;
5  using System.Runtime.CompilerServices;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     public class LinkToItsFrequencyNumberConverter<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 LinkToItsFrequencyNumberConverter(
22             ILinks<TLink> links,
23             IProperty<TLink, TLink> frequencyPropertyOperator,
24             IConverter<TLink> unaryNumberToAddressConverter)
25             : base(links)
26         {
27             _frequencyPropertyOperator = frequencyPropertyOperator;
28             _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
29         }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public TLink Convert(Doublet<TLink> doublet)
33         {
34             var links = _links;
35             var link = links.SearchOrDefault(doublet.Source, doublet.Target);
36             if (_equalityComparer.Equals(link, default))
37             {
38                 throw new ArgumentException($"Link ({doublet}) not found.", nameof(doublet));
39             }
40             var frequency = _frequencyPropertyOperator.Get(link);
41             if (_equalityComparer.Equals(frequency, default))
42             {
43                 return default;
44             }
45             var frequencyNumber = links.GetSource(frequency);
46             return _unaryNumberToAddressConverter.Convert(frequencyNumber);
47         }
48     }
49 }

```

1.115 ./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>,
        ↳ IConverter<int, TLink>
12     {
13         private static readonly EqualityComparer<TLink> _equalityComparer =
        ↳ EqualityComparer<TLink>.Default;
14
15         private readonly TLink[] _unaryNumberPowersOf2;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public PowerOf2ToUnaryNumberConverter(ILinks<TLink> links, TLink one) : base(links)
19         {
20             _unaryNumberPowersOf2 = new TLink[64];
21             _unaryNumberPowersOf2[0] = one;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public TLink Convert(int power)
26         {
27             Ensure.Always.ArgumentInRange(power, new Range<int>(0, _unaryNumberPowersOf2.Length
        ↳ - 1), nameof(power));
28             if (!_equalityComparer.Equals(_unaryNumberPowersOf2[power], default))
29             {
30                 return _unaryNumberPowersOf2[power];
31             }
32             var previousPowerOf2 = Convert(power - 1);
33             var powerOf2 = _links.GetOrCreate(previousPowerOf2, previousPowerOf2);
34             _unaryNumberPowersOf2[power] = powerOf2;
35             return powerOf2;
36         }
37     }
38 }

```

1.116 ./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>,
        ↳ IConverter<TLink>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
        ↳ EqualityComparer<TLink>.Default;
13         private static readonly uncheckedConverter<TLink, ulong> _addressToUInt64Converter =
        ↳ uncheckedConverter<TLink, ulong>.Default;
14         private static readonly uncheckedConverter<ulong, TLink> _uInt64ToAddressConverter =
        ↳ uncheckedConverter<ulong, TLink>.Default;
15         private static readonly TLink _zero = default;
16         private static readonly TLink _one = Arithmetic.Increment(_zero);
17
18         private readonly Dictionary<TLink, TLink> _unaryToUInt64;
19         private readonly TLink _unaryOne;
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>
    ↪ links, TLink unaryOne)
64 {
65     var unaryToUInt64 = new Dictionary<TLink, TLink>
66     {
67         { unaryOne, _one }
68     };
69     var unary = unaryOne;
70     var number = _one;
71     for (var i = 1; i < 64; i++)
72     {
73         unary = links.GetOrCreate(unary, unary);
74         number = Double(number);
75         unaryToUInt64.Add(unary, number);
76     }
77     return unaryToUInt64;
78 }
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 private static TLink Double(TLink number) =>
    ↪ _uint64ToAddressConverter.Convert(_addressToUInt64Converter.Convert(number) * 2UL);
82 }
83 }

```

1.117 ./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>,
    ↪ IConverter<TLink>
12     {
13         private static readonly EqualityComparer<TLink> _equalityComparer =
    ↪ EqualityComparer<TLink>.Default;
14         private static readonly TLink _zero = default;
15         private static readonly TLink _one = Arithmetic.Increment(_zero);
16
17         private readonly IDictionary<TLink, int> _unaryNumberPowerOf2Indicies;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public UnaryNumberToAddressOrOperationConverter(ILinks<TLink> links, IConverter<int,
    ↪ TLink> powerOf2ToUnaryNumberConverter) : base(links) => _unaryNumberPowerOf2Indicies
    ↪ = CreateUnaryNumberPowerOf2IndiciesDictionary(powerOf2ToUnaryNumberConverter);
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public TLink Convert(TLink sourceNumber)
24         {
25             var links = _links;
26             var nullConstant = links.Constants.Null;
27             var source = sourceNumber;
28             var target = nullConstant;
29             if (!_equalityComparer.Equals(source, nullConstant))
30             {

```

```

31         while (true)
32         {
33             if (_unaryNumberPowerOf2Indicies.TryGetValue(source, out int powerOf2Index))
34             {
35                 SetBit(ref target, powerOf2Index);
36                 break;
37             }
38             else
39             {
40                 powerOf2Index = _unaryNumberPowerOf2Indicies[links.GetSource(source)];
41                 SetBit(ref target, powerOf2Index);
42                 source = links.GetTarget(source);
43             }
44         }
45     }
46     return target;
47 }
48
49 [MethodImpl(MethodImplOptions.AggressiveInlining)]
50 private static Dictionary<TLink, int>
    ↳ CreateUnaryNumberPowerOf2IndiciesDictionary(IConverter<int, TLink>
    ↳ powerOf2ToUnaryNumberConverter)
51 {
52     var unaryNumberPowerOf2Indicies = new Dictionary<TLink, int>();
53     for (int i = 0; i < NumericType<TLink>.BitsSize; i++)
54     {
55         unaryNumberPowerOf2Indicies.Add(powerOf2ToUnaryNumberConverter.Convert(i), i);
56     }
57     return unaryNumberPowerOf2Indicies;
58 }
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 private static void SetBit(ref TLink target, int powerOf2Index) => target =
    ↳ Bit.Or(target, Bit.ShiftLeft(_one, powerOf2Index));
62 }
63 }

```

1.118 ./csharp/Platform.Data.Doublets/PropertyOperators/PropertiesOperator.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 PropertiesOperator<TLink> : LinksOperatorBase<TLink>, IProperties<TLink, TLink,
    ↳ TLink>
10     {
11         private static readonly EqualityComparer<TLink> _equalityComparer =
            ↳ EqualityComparer<TLink>.Default;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public PropertiesOperator(ILinks<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public TLink GetValue(TLink @object, TLink property)
18         {
19             var links = _links;
20             var objectProperty = links.SearchOrDefault(@object, property);
21             if (_equalityComparer.Equals(objectProperty, default))
22             {
23                 return default;
24             }
25             var constants = links.Constants;
26             var any = constants.Any;
27             var query = new Link<TLink>(any, objectProperty, any);
28             var valueLink = links.SingleOrDefault(query);
29             if (valueLink == null)
30             {
31                 return default;
32             }
33             return links.GetTarget(valueLink[constants.IndexPart]);
34         }
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public void SetValue(TLink @object, TLink property, TLink value)
38         {
39             var links = _links;

```

```

40         var objectProperty = links.GetOrCreate(@Object, property);
41         links.DeleteMany(links.AllIndices(links.Constants.Any, objectProperty));
42         links.GetOrCreate(objectProperty, value);
43     }
44 }
45 }

```

1.119 ./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 =
12             ⇨ EqualityComparer<TLink>.Default;
13
14         private readonly TLink _propertyMarker;
15         private readonly TLink _propertyValueMarker;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public PropertyOperator(ILinks<TLink> links, TLink propertyMarker, TLink
19             ⇨ propertyValueMarker) : base(links)
20         {
21             _propertyMarker = propertyMarker;
22             _propertyValueMarker = propertyValueMarker;
23         }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public TLink Get(TLink link)
27         {
28             var property = _links.SearchOrDefault(link, _propertyMarker);
29             return GetValue(GetContainer(property));
30         }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         private TLink GetContainer(TLink property)
34         {
35             var valueContainer = default(TLink);
36             if (_equalityComparer.Equals(property, default))
37             {
38                 return valueContainer;
39             }
40             var links = _links;
41             var constants = links.Constants;
42             var countinueConstant = constants.Continue;
43             var breakConstant = constants.Break;
44             var anyConstant = constants.Any;
45             var query = new Link<TLink>(anyConstant, property, anyConstant);
46             links.Each(candidate =>
47             {
48                 var candidateTarget = links.GetTarget(candidate);
49                 var valueTarget = links.GetTarget(candidateTarget);
50                 if (_equalityComparer.Equals(valueTarget, _propertyValueMarker))
51                 {
52                     valueContainer = links.GetIndex(candidate);
53                     return breakConstant;
54                 }
55                 return countinueConstant;
56             }, query);
57             return valueContainer;
58         }
59
60         [MethodImpl(MethodImplOptions.AggressiveInlining)]
61         private TLink GetValue(TLink container) => _equalityComparer.Equals(container, default)
62             ⇨ ? default : _links.GetTarget(container);
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         public void Set(TLink link, TLink value)
66         {
67             var links = _links;
68             var property = links.GetOrCreate(link, _propertyMarker);
69             var container = GetContainer(property);
70             if (_equalityComparer.Equals(container, default))
71             {
72                 links.GetOrCreate(property, value);
73             }
74         }
75     }
76 }

```

```

70     }
71     else
72     {
73         links.Update(container, property, value);
74     }
75 }
76 }
77 }

```

1.120 ./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)
37             {
38                 HalveSequence(sequence, sequence, length);
39                 length = (length / 2) + (length % 2);
40             }
41             return _links.GetOrCreate(sequence[0], sequence[1]);
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 }

```

1.121 ./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<IList<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(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
57             ↪ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache)
58             : this(links, baseConverter, doubletFrequenciesCache, _one, true) { }
59
60         [MethodImpl(MethodImplOptions.AggressiveInlining)]
61         public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
62             ↪ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, bool
63             ↪ doInitialFrequenciesIncrement)
64             : this(links, baseConverter, doubletFrequenciesCache, _one,
65                 ↪ doInitialFrequenciesIncrement) { }
66
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
69             ↪ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, TLink
70             ↪ minFrequencyToCompress, bool doInitialFrequenciesIncrement)
71             : base(links)
72         {
73             _baseConverter = baseConverter;
74             _doubletFrequenciesCache = doubletFrequenciesCache;
75             if (_comparer.Compare(minFrequencyToCompress, _one) < 0)
76             {
77                 minFrequencyToCompress = _one;
78             }
79             _minFrequencyToCompress = minFrequencyToCompress;
80             _doInitialFrequenciesIncrement = doInitialFrequenciesIncrement;
81             ResetMaxDoublet();
82         }
83
84         [MethodImpl(MethodImplOptions.AggressiveInlining)]
85         public override TLink Convert(IList<TLink> source) =>
86             ↪ _baseConverter.Convert(Compress(source));
87
88         /// <remarks>
89         /// Original algorithm idea: https://en.wikipedia.org/wiki/Byte\_pair\_encoding .
90     }
91 }

```

```

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
112                 ↪ frequencies, it is expected that all frequencies for the sequence
113                 ↪ are prepared.");
114             }
115             copy[i - 1].Element = sequence[i - 1];
116             copy[i - 1].DoubletData = data;
117             UpdateMaxDoublet(ref doublet, data);
118         }
119         copy[sequence.Count - 1].Element = sequence[sequence.Count - 1];
120         copy[sequence.Count - 1].DoubletData = new LinkFrequency<TLink>();
121         if (_comparer.Compare(_maxDoubletData.Frequency, default) > 0)
122         {
123             var newLength = ReplaceDoublets(copy);
124             sequence = new TLink[newLength];
125             for (int i = 0; i < newLength; i++)
126             {
127                 sequence[i] = copy[i].Element;
128             }
129         }
130         return sequence;
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++)

```

```

154     {
155         if (_equalityComparer.Equals(copy[r].Element, maxDoubletSource) &&
            ↪ _equalityComparer.Equals(copy[r + 1].Element, maxDoubletTarget))
156         {
157             if (r > 0)
158             {
159                 var previous = copy[w - 1].Element;
160                 copy[w - 1].DoubletData.DecrementFrequency();
161                 copy[w - 1].DoubletData =
                    ↪ _doubletFrequenciesCache.IncrementFrequency(previous,
                    ↪ maxDoubletReplacementLink);
162             }
163             if (r < oldLengthMinusTwo)
164             {
165                 var next = copy[r + 2].Element;
166                 copy[r + 1].DoubletData.DecrementFrequency();
167                 copy[w].DoubletData = _doubletFrequenciesCache.IncrementFrequency(maxDoubletReplacementLink,
                    ↪ next);
168             }
169             copy[w++].Element = maxDoubletReplacementLink;
170             r++;
171             newLength--;
172         }
173         else
174         {
175             copy[w++] = copy[r];
176         }
177     }
178     if (w < newLength)
179     {
180         copy[w] = copy[r];
181     }
182     oldLength = newLength;
183     ResetMaxDoublet();
184     UpdateMaxDoublet(copy, newLength);
185 }
186 return newLength;
187 }
188
189 [MethodImpl(MethodImplOptions.AggressiveInlining)]
190 private void ResetMaxDoublet()
191 {
192     _maxDoublet = new Doublet<TLink>();
193     _maxDoubletData = new LinkFrequency<TLink>();
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 ||
        ↪ (maxFrequency == frequency && doublet.Source + doublet.Target < /* gives better
        ↪ compression string data (and gives collisions quickly) */ _maxDoublet.Source +
        ↪ _maxDoublet.Target)))
213     if (_comparer.Compare(frequency, _minFrequencyToCompress) > 0 &&
214         (_comparer.Compare(maxFrequency, frequency) < 0 ||
            ↪ (_equalityComparer.Equals(maxFrequency, frequency) &&
            ↪ _comparer.Compare(Arithmetic.Add(doublet.Source, doublet.Target),
            ↪ Arithmetic.Add(_maxDoublet.Source, _maxDoublet.Target)) > 0))) /* gives
            ↪ better stability and better compression on sequent data and even on random
            ↪ numbers data (but gives collisions anyway) */
215     {
216         _maxDoublet = doublet;
217         _maxDoubletData = data;
218     }

```

```

219     }
220 }
221 }

```

1.122 ./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     }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Collections.Lists;
4  using Platform.Converters;
5  using Platform.Data.Doublets.Sequences.Frequencies.Cache;
6  using Platform.Data.Doublets.Sequences.Frequencies.Counters;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Sequences.Converters
11 {
12     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)
23         => _sequenceToItsLocalElementLevelsConverter =
24             ↳ sequenceToItsLocalElementLevelsConverter;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public OptimalVariantConverter(ILinks<TLink> links, LinkFrequenciesCache<TLink>
28             ↳ linkFrequenciesCache)
29         : this(links, new SequenceToItsLocalElementLevelsConverter<TLink>(links, new Frequen_
30             ↳ ciesCacheBasedLinkToItsFrequencyNumberConverter<TLink>(linkFrequenciesCache))) { }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public OptimalVariantConverter(ILinks<TLink> links)
34         : this(links, new LinkFrequenciesCache<TLink>(links, new
35             ↳ TotalSequenceSymbolFrequencyCounter<TLink>(links))) { }
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public override TLink Convert(IList<TLink> sequence)
39         {
40             var length = sequence.Count;
41             if (length == 1)
42             {
43                 return sequence[0];
44             }
45             if (length == 2)
46             {
47                 return _links.GetOrCreate(sequence[0], sequence[1]);
48             }
49             sequence = sequence.ToArray();
50             var levels = _sequenceToItsLocalElementLevelsConverter.Convert(sequence);
51             while (length > 2)
52             {
53                 var levelRepeat = 1;

```

```

48     var currentLevel = levels[0];
49     var previousLevel = levels[0];
50     var skipOnce = false;
51     var w = 0;
52     for (var i = 1; i < length; i++)
53     {
54         if (_equalityComparer.Equals(currentLevel, levels[i]))
55         {
56             levelRepeat++;
57             skipOnce = false;
58             if (levelRepeat == 2)
59             {
60                 sequence[w] = _links.GetOrCreate(sequence[i - 1], sequence[i]);
61                 var newLevel = i >= length - 1 ?
62                     GetPreviousLowerThanCurrentOrCurrent(previousLevel,
63                     ↪ currentLevel) :
64                     i < 2 ?
65                     GetNextLowerThanCurrentOrCurrent(currentLevel, levels[i + 1]) :
66                     GetGreatestNeighbourLowerThanCurrentOrCurrent(previousLevel,
67                     ↪ currentLevel, levels[i + 1]);
68                 levels[w] = newLevel;
69                 previousLevel = currentLevel;
70                 w++;
71                 levelRepeat = 0;
72                 skipOnce = true;
73             }
74             else if (i == length - 1)
75             {
76                 sequence[w] = sequence[i];
77                 levels[w] = levels[i];
78                 w++;
79             }
80         }
81         else
82         {
83             currentLevel = levels[i];
84             levelRepeat = 1;
85             if (skipOnce)
86             {
87                 skipOnce = false;
88             }
89             else
90             {
91                 sequence[w] = sequence[i - 1];
92                 levels[w] = levels[i - 1];
93                 previousLevel = levels[w];
94                 w++;
95             }
96             if (i == length - 1)
97             {
98                 sequence[w] = sequence[i];
99                 levels[w] = levels[i];
100                 w++;
101             }
102         }
103     }
104     length = w;
105     return _links.GetOrCreate(sequence[0], sequence[1]);
106 }
107 [MethodImpl(MethodImplOptions.AggressiveInlining)]
108 private static TLink GetGreatestNeighbourLowerThanCurrentOrCurrent(TLink previous, TLink
109 ↪ current, TLink next)
110 {
111     return _comparer.Compare(previous, next) > 0
112         ? _comparer.Compare(previous, current) < 0 ? previous : current
113         : _comparer.Compare(next, current) < 0 ? next : current;
114 }
115 [MethodImpl(MethodImplOptions.AggressiveInlining)]
116 private static TLink GetNextLowerThanCurrentOrCurrent(TLink current, TLink next) =>
117     ↪ _comparer.Compare(next, current) < 0 ? next : current;
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 private static TLink GetPreviousLowerThanCurrentOrCurrent(TLink previous, TLink current)
120     ↪ => _comparer.Compare(previous, current) < 0 ? previous : current;
121 }

```

1.124 ./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>,
10     ↪ IConverter<IList<TLink>>
11     {
12         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
13
14         private readonly IConverter<Doublet<TLink>, TLink> _linkToItsFrequencyToNumberConveter;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public SequenceToItsLocalElementLevelsConverter(ILinks<TLink> links,
18         ↪ IConverter<Doublet<TLink>, TLink> linkToItsFrequencyToNumberConveter) : base(links)
19         ↪ => _linkToItsFrequencyToNumberConveter = linkToItsFrequencyToNumberConveter;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public IList<TLink> Convert(IList<TLink> sequence)
23         {
24             var levels = new TLink[sequence.Count];
25             levels[0] = GetFrequencyNumber(sequence[0], sequence[1]);
26             for (var i = 1; i < sequence.Count - 1; i++)
27             {
28                 var previous = GetFrequencyNumber(sequence[i - 1], sequence[i]);
29                 var next = GetFrequencyNumber(sequence[i], sequence[i + 1]);
30                 levels[i] = _comparer.Compare(previous, next) > 0 ? previous : next;
31             }
32             levels[levels.Length - 1] = GetFrequencyNumber(sequence[sequence.Count - 2],
33             ↪ sequence[sequence.Count - 1]);
34             return levels;
35         }
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public TLink GetFrequencyNumber(TLink source, TLink target) =>
39         ↪ _linkToItsFrequencyToNumberConveter.Convert(new Doublet<TLink>(source, target));
40     }
41 }

```

1.125 ./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 }

```

1.126 ./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)]

```

```

17     public MarkedSequenceCriterionMatcher(ILinks<TLink> links, TLink sequenceMarkerLink)
18     {
19         _links = links;
20         _sequenceMarkerLink = sequenceMarkerLink;
21     }
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     public bool IsMatched(TLink sequenceCandidate)
25     => _equalityComparer.Equals(_links.GetSource(sequenceCandidate), _sequenceMarkerLink)
26     || !_equalityComparer.Equals(_links.SearchOrDefault(_sequenceMarkerLink,
27         ↪ sequenceCandidate), _links.Constants.Null);
28 }

```

1.127 ./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             var cursor = sequence;
33             var links = _links;
34             while (!_equalityComparer.Equals(_heightProvider.Get(cursor), default))
35             {
36                 var source = links.GetSource(cursor);
37                 var target = links.GetTarget(cursor);
38                 if (_equalityComparer.Equals(_heightProvider.Get(source),
39                     ↪ _heightProvider.Get(target)))
40                 {
41                     break;
42                 }
43                 else
44                 {
45                     _stack.Push(source);
46                     cursor = target;
47                 }
48             }
49             var left = cursor;
50             var right = appendant;
51             while (!_equalityComparer.Equals(cursor = _stack.Pop(), links.Constants.Null))
52             {
53                 right = links.GetOrCreate(left, right);
54                 left = cursor;
55             }
56             return links.GetOrCreate(left, right);
57         }
58     }
59 }

```

1.128 ./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 }

```

1.129 ./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         private static readonly UncheckedConverter<ulong, TLink> _uInt64ToAddressConverter =
27             ↪ UncheckedConverter<ulong, TLink>.Default;
28
29         private readonly ILinks<TLink> _links;
30         private readonly ILinks<TLink> _sequences;
31         private HashSet<KeyValuePair<IList<TLink>, IList<TLink>>> _groups;
32         private BitString _visited;
33
34         private class ItemEquilityComparer : IEqualityComparer<KeyValuePair<IList<TLink>,
35             ↪ IList<TLink>>>
36         {
37             private readonly IListEqualityComparer<TLink> _listComparer;
38
39             public ItemEquilityComparer() => _listComparer =
40                 ↪ Default<IListEqualityComparer<TLink>>.Instance;
41
42             [MethodImpl(MethodImplOptions.AggressiveInlining)]
43             public bool Equals(KeyValuePair<IList<TLink>, IList<TLink>> left,
44                 ↪ KeyValuePair<IList<TLink>, IList<TLink>> right) =>
45                 ↪ _listComparer.Equals(left.Key, right.Key) && _listComparer.Equals(left.Value,
46                 ↪ right.Value);
47
48             [MethodImpl(MethodImplOptions.AggressiveInlining)]
49             public int GetHashCode(KeyValuePair<IList<TLink>, IList<TLink>> pair) =>
50                 ↪ (_listComparer.GetHashCode(pair.Key),
51                 ↪ _listComparer.GetHashCode(pair.Value)).GetHashCode();
52         }
53
54         private class ItemComparer : IComparer<KeyValuePair<IList<TLink>, IList<TLink>>>
55         {
56             private readonly IListComparer<TLink> _listComparer;
57
58             [MethodImpl(MethodImplOptions.AggressiveInlining)]
59             public ItemComparer() => _listComparer = Default<IListComparer<TLink>>.Instance;
60         }
61     }
62 }

```



```

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
145             ↪ ashSet<ulong>)(object)readAsElement,
146             ↪ (IList<ulong>)segment);
147         foreach (var partiallyMatchedSequence in partiallyMatched)
148         {
149             var sequenceIndex =
150                 ↪ _uInt64ToAddressConverter.Convert(partiallyMatchedSequence);
151             duplicates.Add(sequenceIndex);
152         }
153     }
154     duplicates.Sort();
155     return duplicates;
156 }
157
158 [MethodImpl(MethodImplOptions.AggressiveInlining)]
159 private void PrintDuplicates(KeyValuePair<IList<TLink>, IList<TLink>> duplicatesItem)
160 {
161     if (!(_links is ILinks<ulong> ulongLinks))
162     {
163         return;
164     }
165     var duplicatesKey = duplicatesItem.Key;
166     var keyString = UnicodeMap.FromLinksToString((IList<ulong>)duplicatesKey);
167     Console.WriteLine($"> {keyString} ({string.Join(", ", duplicatesKey)}");
168     var duplicatesList = duplicatesItem.Value;
169     for (int i = 0; i < duplicatesList.Count; i++)
170     {
171         var sequenceIndex = _addressToUInt64Converter.Convert(duplicatesList[i]);
172         var formattedSequenceStructure = ulongLinks.FormatStructure(sequenceIndex, x =>
173             ↪ Point<ulong>.IsPartialPoint(x), (sb, link) => _ =
174             ↪ UnicodeMap.IsCharLink(link.Index) ?
175             ↪ sb.Append(UnicodeMap.FromLinkToChar(link.Index)) : sb.Append(link.Index));
176         Console.WriteLine(formattedSequenceStructure);
177         var sequenceString = UnicodeMap.FromSequenceLinkToString(sequenceIndex,
178             ↪ ulongLinks);
179         Console.WriteLine(sequenceString);
180     }
181     Console.WriteLine();
182 }
183 }
184 }

```

1.130 ./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).

```

```

13  /// TODO: Extract interface to implement frequencies storage inside Links storage
14  /// </remarks>
15  public class LinkFrequenciesCache<TLink> : LinksOperatorBase<TLink>
16  {
17      private static readonly EqualityComparer<TLink> _equalityComparer =
18          ↳ EqualityComparer<TLink>.Default;
19      private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
20
21      private static readonly TLink _zero = default;
22      private static readonly TLink _one = Arithmetic.Increment(_zero);
23
24      private readonly Dictionary<Doublet<TLink>, LinkFrequency<TLink>> _doubletsCache;
25      private readonly ICounter<TLink, TLink> _frequencyCounter;
26
27      [MethodImpl(MethodImplOptions.AggressiveInlining)]
28      public LinkFrequenciesCache(ILinks<TLink> links, ICounter<TLink, TLink> frequencyCounter)
29          : base(links)
30      {
31          _doubletsCache = new Dictionary<Doublet<TLink>, LinkFrequency<TLink>>(4096,
32              ↳ DoubletComparer<TLink>.Default);
33          _frequencyCounter = frequencyCounter;
34      }
35
36      [MethodImpl(MethodImplOptions.AggressiveInlining)]
37      public LinkFrequency<TLink> GetFrequency(TLink source, TLink target)
38      {
39          var doublet = new Doublet<TLink>(source, target);
40          return GetFrequency(ref doublet);
41      }
42
43      [MethodImpl(MethodImplOptions.AggressiveInlining)]
44      public LinkFrequency<TLink> GetFrequency(ref Doublet<TLink> doublet)
45      {
46          _doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data);
47          return data;
48      }
49
50      [MethodImpl(MethodImplOptions.AggressiveInlining)]
51      public void IncrementFrequencies(IList<TLink> sequence)
52      {
53          for (var i = 1; i < sequence.Count; i++)
54          {
55              IncrementFrequency(sequence[i - 1], sequence[i]);
56          }
57      }
58
59      [MethodImpl(MethodImplOptions.AggressiveInlining)]
60      public LinkFrequency<TLink> IncrementFrequency(TLink source, TLink target)
61      {
62          var doublet = new Doublet<TLink>(source, target);
63          return IncrementFrequency(ref doublet);
64      }
65
66      [MethodImpl(MethodImplOptions.AggressiveInlining)]
67      public void PrintFrequencies(IList<TLink> sequence)
68      {
69          for (var i = 1; i < sequence.Count; i++)
70          {
71              PrintFrequency(sequence[i - 1], sequence[i]);
72          }
73      }
74
75      [MethodImpl(MethodImplOptions.AggressiveInlining)]
76      public void PrintFrequency(TLink source, TLink target)
77      {
78          var number = GetFrequency(source, target).Frequency;
79          Console.WriteLine("{0},{1}) - {2}", source, target, number);
80      }
81
82      [MethodImpl(MethodImplOptions.AggressiveInlining)]
83      public LinkFrequency<TLink> IncrementFrequency(ref Doublet<TLink> doublet)
84      {
85          if (_doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data))
86          {
87              data.IncrementFrequency();
88          }
89          else
90          {
91              var link = _links.SearchOrDefault(doublet.Source, doublet.Target);

```

```

90     data = new LinkFrequency<TLink>(_one, link);
91     if (!_equalityComparer.Equals(link, default))
92     {
93         data.Frequency = Arithmetic.Add(data.Frequency,
94             ↪ _frequencyCounter.Count(link));
95     }
96     _doubletsCache.Add(doublet, data);
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             // TODO: 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             //}
132         }
133     }
134 }

```

1.131 ./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 }

```

1.132 ./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 }

```

1.133 ./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         : base(links, sequenceLink, symbol)
17         => _markedSequenceMatcher = markedSequenceMatcher;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public override TLink Count()
21         {
22             if (!_markedSequenceMatcher.IsMatched(_sequenceLink))
23             {
24                 return default;
25             }
26             return base.Count();
27         }
28     }
29 }

```

1.134 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/SequenceSymbolFrequencyOneOffCounter.cs

```

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 }

```

```

20
21 [MethodImpl(MethodImplOptions.AggressiveInlining)]
22 public SequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links, TLink sequenceLink,
    ↪ TLink symbol)
23 {
24     _links = links;
25     _sequenceLink = sequenceLink;
26     _symbol = symbol;
27     _total = default;
28 }
29
30 [MethodImpl(MethodImplOptions.AggressiveInlining)]
31 public virtual TLink Count()
32 {
33     if (_comparer.Compare(_total, default) > 0)
34     {
35         return _total;
36     }
37     StopableSequenceWalker.WalkRight(_sequenceLink, _links.GetSource, _links.GetTarget,
    ↪ IsElement, VisitElement);
38     return _total;
39 }
40
41 [MethodImpl(MethodImplOptions.AggressiveInlining)]
42 private bool IsElement(TLink x) => _equalityComparer.Equals(x, _symbol) ||
    ↪ _links.IsPartialPoint(x); // TODO: Use SequenceElementCriteriaMatcher instead of
    ↪ IsPartialPoint
43
44 [MethodImpl(MethodImplOptions.AggressiveInlining)]
45 private bool VisitElement(TLink element)
46 {
47     if (_equalityComparer.Equals(element, _symbol))
48     {
49         _total = Arithmetic.Increment(_total);
50     }
51     return true;
52 }
53 }
54 }

```

1.135 ./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,
    ↪ ICriterionMatcher<TLink> markedSequenceMatcher)
15         {
16             _links = links;
17             _markedSequenceMatcher = markedSequenceMatcher;
18         }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public TLink Count(TLink argument) => new
    ↪ TotalMarkedSequenceSymbolFrequencyOneOffCounter<TLink>(_links,
    ↪ _markedSequenceMatcher, argument).Count();
22     }
23 }

```

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

```

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> :
    ↪ TotalSequenceSymbolFrequencyOneOffCounter<TLink>

```

```

10 {
11     private readonly ICriterionMatcher<TLink> _markedSequenceMatcher;
12
13     [MethodImpl(MethodImplOptions.AggressiveInlining)]
14     public TotalMarkedSequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links,
15         ↳ ICriterionMatcher<TLink> markedSequenceMatcher, TLink symbol)
16         : base(links, symbol)
17         => _markedSequenceMatcher = markedSequenceMatcher;
18
19     [MethodImpl(MethodImplOptions.AggressiveInlining)]
20     protected override void CountSequenceSymbolFrequency(TLink link)
21     {
22         var symbolFrequencyCounter = new
23             ↳ MarkedSequenceSymbolFrequencyOneOffCounter<TLink>(_links,
24                 ↳ _markedSequenceMatcher, link, _symbol);
25         _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
26     }
27 }

```

1.137 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyCounter

```

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

```

1.138 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyOneOffCounter

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Interfaces;
4 using Platform.Numbers;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
9 {
10     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 }

```

```

38     }
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     private void CountCore(TLink link)
42     {
43         var any = _links.Constants.Any;
44         if (_equalityComparer.Equals(_links.Count(any, link), default))
45         {
46             CountSequenceSymbolFrequency(link);
47         }
48         else
49         {
50             _links.Each(EachElementHandler, any, link);
51         }
52     }
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected virtual void CountSequenceSymbolFrequency(TLink link)
56     {
57         var symbolFrequencyCounter = new SequenceSymbolFrequencyOneOffCounter<TLink>(_links,
58             ↪ link, _symbol);
59         _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
60     }
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     private TLink EachElementHandler(IList<TLink> doublet)
64     {
65         var constants = _links.Constants;
66         var doubletIndex = doublet[constants.IndexPart];
67         if (_visits.Add(doubletIndex))
68         {
69             CountCore(doubletIndex);
70         }
71         return constants.Continue;
72     }
73 }

```

1.139 ./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         height = _baseHeightProvider.Get(sequence);
43         heightValue = _addressToUnaryNumberConverter.Convert(height);
44         _propertyOperator.SetValue(sequence, _heightPropertyMarker, heightValue);
45     }
46     else
47     {
48         height = _unaryNumberToAddressConverter.Convert(heightValue);
49     }
50     return height;
51 }
52 }
53 }

```

1.140 ./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     }
31 }

```

1.141 ./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 }

```

1.142 ./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)]

```

```

19     public bool Add(ICollection<TLink> sequence)
20     {
21         var indexed = true;
22         var i = sequence.Count;
23         while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
24             { }
25         for (; i >= 1; i--)
26         {
27             _cache.IncrementFrequency(sequence[i - 1], sequence[i]);
28         }
29         return indexed;
30     }
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     private bool IsIndexedWithIncrement(TLink source, TLink target)
33     {
34         var frequency = _cache.GetFrequency(source, target);
35         if (frequency == null)
36         {
37             return false;
38         }
39         var indexed = !_equalityComparer.Equals(frequency.Frequency, default);
40         if (indexed)
41         {
42             _cache.IncrementFrequency(source, target);
43         }
44         return indexed;
45     }
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     public bool MightContain(ICollection<TLink> sequence)
49     {
50         var indexed = true;
51         var i = sequence.Count;
52         while (--i >= 1 && (indexed = IsIndexed(sequence[i - 1], sequence[i]))) { }
53         return indexed;
54     }
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     private bool IsIndexed(TLink source, TLink target)
58     {
59         var frequency = _cache.GetFrequency(source, target);
60         if (frequency == null)
61         {
62             return false;
63         }
64         return !_equalityComparer.Equals(frequency.Frequency, default);
65     }
66 }
67 }

```

1.143 ./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(ICollection<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)]

```

```

26     public override bool Add(ICollection<TLink> sequence)
27     {
28         var indexed = true;
29         var i = sequence.Count;
30         while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
31             { }
32         for (; i >= 1; i--)
33         {
34             Increment(_links.GetOrCreate(sequence[i - 1], sequence[i]));
35         }
36         return indexed;
37     }
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     private bool IsIndexedWithIncrement(TLink source, TLink target)
40     {
41         var link = _links.SearchOrCreate(source, target);
42         var indexed = !_equalityComparer.Equals(link, default);
43         if (indexed)
44         {
45             Increment(link);
46         }
47         return indexed;
48     }
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     private void Increment(TLink link)
51     {
52         var previousFrequency = _frequencyPropertyOperator.Get(link);
53         var frequency = _frequencyIncrementer.Increment(previousFrequency);
54         _frequencyPropertyOperator.Set(link, frequency);
55     }
56 }
57 }
58 }

```

1.144 ./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(ICollection<TLink> sequence);
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         bool MightContain(ICollection<TLink> sequence);
20     }
21 }

```

1.145 ./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(ICollection<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public virtual bool Add(ICollection<TLink> sequence)
18         {
19             var indexed = true;
20             var i = sequence.Count;

```

```

20         while (--i >= 1 && (indexed =
           ↳ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
           ↳ default))) { }
21     for (; i >= 1; i--)
22     {
23         _links.GetOrCreate(sequence[i - 1], sequence[i]);
24     }
25     return indexed;
26 }
27
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 public virtual bool MightContain(ICollection<TLink> sequence)
30 {
31     var indexed = true;
32     var i = sequence.Count;
33     while (--i >= 1 && (indexed =
           ↳ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
           ↳ default))) { }
34     return indexed;
35 }
36 }
37 }

```

1.146 ./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 =
           ↳ EqualityComparer<TLink>.Default;
11
12         private readonly ISynchronizedLinks<TLink> _links;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public SynchronizedSequenceIndex(ISynchronizedLinks<TLink> links) => _links = links;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public bool Add(ICollection<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 =
                   ↳ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
                   ↳ sequence[i]), default))) { }
26             });
27             if (!indexed)
28             {
29                 _links.SyncRoot.ExecuteWriteOperation(() =>
30                 {
31                     for (; i >= 1; i--)
32                     {
33                         links.GetOrCreate(sequence[i - 1], sequence[i]);
34                     }
35                 });
36             }
37             return indexed;
38         }
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 =
                   ↳ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
                   ↳ sequence[i]), default))) { }
49                 return indexed;
50             });
51         }
52     }
53 }

```

```

51     }
52 }
53 }

```

1.147 ./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(IList<TLink> sequence) => false;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public virtual bool MightContain(IList<TLink> sequence) => true;
15     }
16 }

```

1.148 ./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 sequence[startAt..stopAt];
59                 }
60                 var mid = (startAt + stopAt) / 2;
61                 var left = CreateAllVariants2Core(sequence, startAt, mid);
62                 var right = CreateAllVariants2Core(sequence, mid + 1, stopAt);
63                 var result = new ulong[left.Length + right.Length];
64                 left.CopyTo(result, 0);
65                 right.CopyTo(result, left.Length);
66                 return result;
67             }
68         }
69     }
70 }

```

```

57         return new[] { sequence[startAt] };
58     }
59     if ((stopAt - startAt) == 1)
60     {
61         return new[] { Links.Unsync.GetOrCreate(sequence[startAt], sequence[stopAt]) };
62     }
63     var variants = new ulong[(ulong)Platform.Numbers.Math.Catalan(stopAt - startAt)];
64     var last = 0;
65     for (var splitter = startAt; splitter < stopAt; splitter++)
66     {
67         var left = CreateAllVariants2Core(sequence, startAt, splitter);
68         var right = CreateAllVariants2Core(sequence, splitter + 1, stopAt);
69         for (var i = 0; i < left.Length; i++)
70         {
71             for (var j = 0; j < right.Length; j++)
72             {
73                 var variant = Links.Unsync.GetOrCreate(left[i], right[j]);
74                 if (variant == Constants.Null)
75                 {
76                     throw new NotImplementedException("Creation cancellation is not
77                                     ↳ implemented.");
78                 }
79                 variants[last++] = variant;
80             }
81         }
82     }
83     return variants;
84 }
85 [MethodImpl(MethodImplOptions.AggressiveInlining)]
86 public List<ulong> CreateAllVariants1(params ulong[] sequence)
87 {
88     return _sync.ExecuteWriteOperation(() =>
89     {
90         if (sequence.IsNullOrEmpty())
91         {
92             return new List<ulong>();
93         }
94         Links.Unsync.EnsureLinkExists(sequence);
95         if (sequence.Length == 1)
96         {
97             return new List<ulong> { sequence[0] };
98         }
99         var results = new
100             ↳ List<ulong>((int)Platform.Numbers.Math.Catalan(sequence.Length));
101         return CreateAllVariants1Core(sequence, results);
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
113                                     ↳ implemented.");
114         }
115         results.Add(link);
116         return results;
117     }
118     var innerSequenceLength = sequence.Length - 1;
119     var innerSequence = new ulong[innerSequenceLength];
120     for (var li = 0; li < innerSequenceLength; li++)
121     {
122         var link = Links.Unsync.GetOrCreate(sequence[li], sequence[li + 1]);
123         if (link == Constants.Null)
124         {
125             throw new NotImplementedException("Creation cancellation is not
126                                     ↳ implemented.");
127         }
128         for (var isi = 0; isi < li; isi++)
129         {
130             innerSequence[isi] = sequence[isi];
131         }
132         innerSequence[li] = link;
133     }

```

```

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                     innerSequence[linkIndex] = doublet[Constants.IndexPart];
191                     Each1(handler, innerSequence);
192                     return Constants.Continue;
193                 }
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     })
211 }

```

```

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     else if (sequence.Length == 2)
253     {
254         //_links.Each(sequence[0], sequence[1], handler);
255         // o_|      x_o ...
256         // x_|      |__|
257         Links.Each(sequence[1], Constants.Any, doublet =>
258         {
259             var match = Links.SearchOrDefault(sequence[0], doublet);
260             if (match != Constants.Null)
261             {
262                 handler(new LinkAddress<LinkIndex>(match));
263             }
264             return true;
265         });
266         // |_x      ... x_o
267         // |_o      |__|
268         Links.Each(Constants.Any, sequence[0], doublet =>
269         {
270             var match = Links.SearchOrDefault(doublet, sequence[1]);
271             if (match != 0)
272             {
273                 handler(new LinkAddress<LinkIndex>(match));
274             }
275             return true;
276         });
277         //      . _x o _
278         //      |__|
279         PartialStepRight(x => handler(x), sequence[0], sequence[1]);
280     }
281     else
282     {
283         throw new NotImplementedException();
284     }
285 }
286
287 [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                     StoppableSequenceWalker.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                     }
439                     return true;
440                 });
441                 if (filterPosition == sequence.Length)
442                 {
443                     results.Add(resultIndex);
444                 }
445             }
446         });
447     }

```

```

442     }
443 }
444 if (sequence.Length >= 2)
445 {
446     StepRight(handler, sequence[0], sequence[1]);
447 }
448 var last = sequence.Length - 2;
449 for (var i = 1; i < last; i++)
450 {
451     PartialStepRight(handler, sequence[i], sequence[i + 1]);
452 }
453 if (sequence.Length >= 3)
454 {
455     StepLeft(handler, sequence[sequence.Length - 2],
456         ↪ sequence[sequence.Length - 1]);
457 }
458 return results;
459 });
460 }
461
462 [MethodImpl(MethodImplOptions.AggressiveInlining)]
463 public HashSet<ulong> GetAllMatchingSequences1(params ulong[] sequence)
464 {
465     return _sync.ExecuteReadOperation(() =>
466     {
467         var results = new HashSet<ulong>();
468         if (sequence.Length > 0)
469         {
470             Links.EnsureLinkExists(sequence);
471             var firstElement = sequence[0];
472             if (sequence.Length == 1)
473             {
474                 results.Add(firstElement);
475                 return results;
476             }
477             if (sequence.Length == 2)
478             {
479                 var doublet = Links.SearchOrDefault(firstElement, sequence[1]);
480                 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
507 public const int MaxSequenceFormatSize = 200;
508
509 [MethodImpl(MethodImplOptions.AggressiveInlining)]
510 public string FormatSequence(LinkIndex sequenceLink, params LinkIndex[] knownElements)
511     ↪ => FormatSequence(sequenceLink, (sb, x) => sb.Append(x), true, knownElements);
512
513 [MethodImpl(MethodImplOptions.AggressiveInlining)]
514 public string FormatSequence(LinkIndex sequenceLink, Action<StringBuilder, LinkIndex>
515     ↪ elementToString, bool insertComma, params LinkIndex[] knownElements) =>
516     ↪ Links.SyncRoot.ExecuteReadOperation(() => FormatSequence(Links.Unsync, sequenceLink,
517     ↪ elementToString, insertComma, knownElements));

```

```

513 [MethodImpl(MethodImplOptions.AggressiveInlining)]
514 private string FormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
    ↳ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
    ↳ LinkIndex[] knownElements)
515 {
516     var linksInSequence = new HashSet<ulong>(knownElements);
517     //var entered = new HashSet<ulong>();
518     var sb = new StringBuilder();
519     sb.Append('{');
520     if (links.Exists(sequenceLink))
521     {
522         StopableSequenceWalker.WalkRight(sequenceLink, links.GetSource, links.GetTarget,
523             x => linksInSequence.Contains(x) || links.IsPartialPoint(x), element => //
    ↳ entered.AddAndReturnVoid, x => { }, entered.DoNotContains
524         {
525             if (insertComma && sb.Length > 1)
526             {
527                 sb.Append(',');
528             }
529             //if (entered.Contains(element))
530             //{
531             //    sb.Append('{');
532             //    elementToString(sb, element);
533             //    sb.Append('}');
534             //}
535             //else
536             elementToString(sb, element);
537             if (sb.Length < MaxSequenceFormatSize)
538             {
539                 return true;
540             }
541             sb.Append(insertComma ? ", ..." : "...");
542             return false;
543         });
544     }
545     sb.Append('}');
546     return sb.ToString();
547 }
548
549 [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),
    ↳ entered.AddAndReturnVoid, x => { }, entered.DoNotContains, element =>
566         {
567             if (insertComma && sb.Length > 1)
568             {
569                 sb.Append(',');
570             }
571             if (entered.Contains(element))
572             {
573                 sb.Append('{');
574                 elementToString(sb, element);
575                 sb.Append('}');
576             }
577             else
578             {

```

```

579         elementToString(sb, element);
580     }
581     if (sb.Length < MaxSequenceFormatSize)
582     {
583         return true;
584     }
585     sb.Append(insertComma ? ", ..." : "...");
586     return false;
587 });
588 }
589 sb.Append('}');
590 return sb.ToString();
591 }
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                     if (filterPosition >= 0)
621                     {
622                         if (x == sequence[filterPosition + 1])
623                         {
624                             filterPosition++;
625                         }
626                         else
627                         {
628                             return false;
629                         }
630                     }
631                     if (filterPosition < 0)
632                     {
633                         if (x == sequence[0])
634                         {
635                             filterPosition = 0;
636                         }
637                     }
638                     return true;
639                 }
640             });
641             if (filterPosition == (sequence.Length - 1))
642             {
643                 filteredResults.Add(result);
644             }
645         }
646         return filteredResults;
647     }
648     return new List<ulong>();
649 });
650 }
651
652 [MethodImpl(MethodImplOptions.AggressiveInlining)]
653 public HashSet<ulong> GetAllPartiallyMatchingSequences1(params ulong[] sequence)
654 {
655     return _sync.ExecuteReadOperation(() =>

```

```

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
697 //public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
698 //{
699 //    return Sync.ExecuteReadOperation(() =>
700 //    {
701 //        if (sequence.Length > 0)
702 //        {
703 //            _links.EnsureEachLinkIsAnyOrExists(sequence);
704 //
705 //            var firstResults = new HashSet<ulong>();
706 //            var lastResults = new HashSet<ulong>();
707 //
708 //            var first = sequence.First(x => x != LinksConstants.Any);
709 //            var last = sequence.Last(x => x != LinksConstants.Any);
710 //
711 //            AllUsagesCore(first, firstResults);
712 //            AllUsagesCore(last, lastResults);
713 //
714 //            firstResults.IntersectWith(lastResults);
715 //
716 //            //for (var i = 0; i < sequence.Length; i++)
717 //            //    AllUsagesCore(sequence[i], results);
718 //
719 //            var filteredResults = new HashSet<ulong>();
720 //            var matcher = new Matcher(this, sequence, filteredResults, null);
721 //            matcher.AddAllPartialMatchedToResults(firstResults);
722 //            return filteredResults;
723 //        }
724 //
725 //        return new HashSet<ulong>();
726 //    });
727 //}
728
729 [MethodImpl(MethodImplOptions.AggressiveInlining)]
730 public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
731 {
732     return _sync.ExecuteReadOperation((Func<HashSet<ulong>>)(() =>
733     {
734         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 [MethodImpl(MethodImplOptions.AggressiveInlining)]
755 public HashSet<ulong> GetAllPartiallyMatchingSequences4(HashSet<ulong> readAsElements,
756     ↳ IList<ulong> sequence)
757 {
758     return _sync.ExecuteReadOperation(() =>
759     {
760         if (sequence.Count > 0)
761         {
762             Links.EnsureLinkExists(sequence);
763             var results = new HashSet<LinkIndex>();
764             //var nextResults = new HashSet<ulong>();
765             //for (var i = 0; i < sequence.Length; i++)
766             //{
767             //    AllUsagesCore(sequence[i], nextResults);
768             //    if (results.IsNullOrEmpty())
769             //    {
770             //        results = nextResults;
771             //        nextResults = new HashSet<ulong>();
772             //    }
773             //    else
774             //    {
775             //        results.IntersectWith(nextResults);
776             //        nextResults.Clear();
777             //    }
778             //}
779             var collector1 = new AllUsagesCollector1(Links.Unsync, results);
780             collector1.Collect(Links.Unsync.GetLink(sequence[0]));
781             var next = new HashSet<ulong>();
782             for (var i = 1; i < sequence.Count; i++)
783             {
784                 var collector = new AllUsagesCollector1(Links.Unsync, next);
785                 collector.Collect(Links.Unsync.GetLink(sequence[i]));
786
787                 results.IntersectWith(next);
788                 next.Clear();
789             }
790             var filteredResults = new HashSet<ulong>();
791             var matcher = new Matcher(this, sequence, filteredResults, null,
792                 ↳ readAsElements);
793             matcher.AddAllPartialMatchedToResultsAndReadAsElements(results.OrderBy(x =>
794                 ↳ x)); // OrderBy is a Hack
795             return filteredResults;
796         }
797         return new HashSet<ulong>();
798     });
799 }
800
801 // Does not work
802 //public HashSet<ulong> GetAllPartiallyMatchingSequences5(HashSet<ulong> readAsElements,
803 //    ↳ params ulong[] sequence)
804 //{
805 //    var visited = new HashSet<ulong>();
806 //    var results = new HashSet<ulong>();
807 //    var matcher = new Matcher(this, sequence, visited, x => { results.Add(x); return
808 //        ↳ true; }, readAsElements);
809 //    var last = sequence.Length - 1;

```

```

805 //     for (var i = 0; i < last; i++)
806 //     {
807 //         PartialStepRight(matcher.PartialMatch, sequence[i], sequence[i + 1]);
808 //     }
809 //     return results;
810 // }
811
812 [MethodImpl(MethodImplOptions.AggressiveInlining)]
813 public List<ulong> GetAllPartiallyMatchingSequences(params ulong[] sequence)
814 {
815     return _sync.ExecuteReadOperation(() =>
816     {
817         if (sequence.Length > 0)
818         {
819             Links.EnsureLinkExists(sequence);
820             //var firstElement = sequence[0];
821             //if (sequence.Length == 1)
822             //{
823             //    //results.Add(firstElement);
824             //    return results;
825             //}
826             //if (sequence.Length == 2)
827             //{
828             //    //var doublet = _links.SearchCore(firstElement, sequence[1]);
829             //    //if (doublet != Doublets.Links.Null)
830             //    //    results.Add(doublet);
831             //    return results;
832             //}
833             //var lastElement = sequence[sequence.Length - 1];
834             //Func<ulong, bool> handler = x =>
835             //{
836             //    if (StartsWith(x, firstElement) && EndsWith(x, lastElement))
837             //        results.Add(x);
838             //    return true;
839             //};
840             //if (sequence.Length >= 2)
841             //    StepRight(handler, sequence[0], sequence[1]);
842             //var last = sequence.Length - 2;
843             //for (var i = 1; i < last; i++)
844             //    PartialStepRight(handler, sequence[i], sequence[i + 1]);
845             //if (sequence.Length >= 3)
846             //    StepLeft(handler, sequence[sequence.Length - 2],
847             //        sequence[sequence.Length - 1]);
848             //if (sequence.Length == 1)
849             //    throw new NotImplementedException(); // all sequences, containing
850             //        this element?
851             //if (sequence.Length == 2)
852             //{
853             //    var results = new List<ulong>();
854             //    PartialStepRight(results.Add, sequence[0], sequence[1]);
855             //    return results;
856             //}
857             //var matches = new List<List<ulong>>();
858             //var last = sequence.Length - 1;
859             //for (var i = 0; i < last; i++)
860             //{
861             //    var results = new List<ulong>();
862             //    //StepRight(results.Add, sequence[i], sequence[i + 1]);
863             //    PartialStepRight(results.Add, sequence[i], sequence[i + 1]);
864             //    if (results.Count > 0)
865             //        matches.Add(results);
866             //    else
867             //        return results;
868             //    if (matches.Count == 2)
869             //    {
870             //        var merged = new List<ulong>();
871             //        for (var j = 0; j < matches[0].Count; j++)
872             //            for (var k = 0; k < matches[1].Count; k++)
873             //                CloseInnerConnections(merged.Add, matches[0][j],
874             //                    matches[1][k]);
875             //        if (merged.Count > 0)
876             //            matches = new List<List<ulong>> { merged };
877             //        else
878             //            return new List<ulong>();
879             //    }
880             //}
881         }
882     });
883 }

```



```

878         //}
879         //if (matches.Count > 0)
880         //{
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         //}
891         var firstLinkUsages = new HashSet<ulong>();
892         AllUsagesCore(sequence[0], firstLinkUsages);
893         firstLinkUsages.Add(sequence[0]);
894         //var previousMatchings = firstLinkUsages.ToList(); //new List<ulong>() {
895         //    sequence[0] }; // or all sequences, containing this element?
896         //return GetAllPartiallyMatchingSequencesCore(sequence, firstLinkUsages,
897         //    1).ToList();
898         var results = new HashSet<ulong>();
899         foreach (var match in GetAllPartiallyMatchingSequencesCore(sequence,
900             //    firstLinkUsages, 1))
901             {
902                 AllUsagesCore(match, results);
903             }
904         return results.ToList();
905     }
906     return new List<ulong>();
907 });
908 }
909
910 /// <remarks>
911 /// TODO: Может потребоваться ограничение на уровень глубины рекурсии
912 /// </remarks>
913 [MethodImpl(MethodImplOptions.AggressiveInlining)]
914 public HashSet<ulong> AllUsages(ulong link)
915 {
916     return _sync.ExecuteReadOperation(() =>
917     {
918         var usages = new HashSet<ulong>();
919         AllUsagesCore(link, usages);
920         return usages;
921     });
922 }
923
924 // При сборе всех использований (последовательностей) можно сохранять обратный путь к
925 // той связи с которой начинался поиск (STTTSSSTT),
926 // причём достаточно одного бита для хранения перехода влево или вправо
927 [MethodImpl(MethodImplOptions.AggressiveInlining)]
928 private void AllUsagesCore(ulong link, HashSet<ulong> usages)
929 {
930     bool handler(ulong doublet)
931     {
932         if (usages.Add(doublet))
933         {
934             AllUsagesCore(doublet, usages);
935         }
936         return true;
937     }
938     Links.Unsync.Each(link, Constants.Any, handler);
939     Links.Unsync.Each(Constants.Any, link, handler);
940 }
941
942 [MethodImpl(MethodImplOptions.AggressiveInlining)]
943 public HashSet<ulong> AllBottomUsages(ulong link)
944 {
945     return _sync.ExecuteReadOperation(() =>
946     {
947         var visits = new HashSet<ulong>();
948         var usages = new HashSet<ulong>();
949         AllBottomUsagesCore(link, visits, usages);
950         return usages;
951     });
952 }
953
954 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

951 private void AllBottomUsagesCore(ulong link, HashSet<ulong> visits, HashSet<ulong>
    ↳ usages)
952 {
953     bool handler(ulong doublet)
954     {
955         if (visits.Add(doublet))
956         {
957             AllBottomUsagesCore(doublet, visits, usages);
958         }
959         return true;
960     }
961     if (Links.Unsync.Count(Constants.Any, link) == 0)
962     {
963         usages.Add(link);
964     }
965     else
966     {
967         Links.Unsync.Each(link, Constants.Any, handler);
968         Links.Unsync.Each(Constants.Any, link, handler);
969     }
970 }
971
972 [MethodImpl(MethodImplOptions.AggressiveInlining)]
973 public ulong CalculateTotalSymbolFrequencyCore(ulong symbol)
974 {
975     if (Options.UseSequenceMarker)
976     {
977         var counter = new TotalMarkedSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
978             ↳ Options.MarkedSequenceMatcher, symbol);
979         return counter.Count();
980     }
981     else
982     {
983         var counter = new TotalSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
984             ↳ symbol);
985         return counter.Count();
986     }
987 }
988
989 [MethodImpl(MethodImplOptions.AggressiveInlining)]
990 private bool AllUsagesCore1(ulong link, HashSet<ulong> usages, Func<IList<LinkIndex>,
    ↳ LinkIndex> outerHandler)
991 {
992     bool handler(ulong doublet)
993     {
994         if (usages.Add(doublet))
995         {
996             if (outerHandler(new LinkAddress<LinkIndex>(doublet)) != Constants.Continue)
997             {
998                 return false;
999             }
1000             if (!AllUsagesCore1(doublet, usages, outerHandler))
1001             {
1002                 return false;
1003             }
1004         }
1005         return true;
1006     }
1007     return Links.Unsync.Each(link, Constants.Any, handler)
1008         && Links.Unsync.Each(Constants.Any, link, handler);
1009 }
1010
1011 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1012 public void CalculateAllUsages(ulong[] totals)
1013 {
1014     var calculator = new AllUsagesCalculator(Links, totals);
1015     calculator.Calculate();
1016 }
1017
1018 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1019 public void CalculateAllUsages2(ulong[] totals)
1020 {
1021     var calculator = new AllUsagesCalculator2(Links, totals);
1022     calculator.Calculate();
1023 }
1024
1025 private class AllUsagesCalculator
1026 {

```

```

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     _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(IList<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
1223 private class AllUsagesIntersectingCollector
1224 {
1225     private readonly SynchronizedLinks<ulong> _links;
1226     private readonly HashSet<ulong> _intersectWith;
1227     private readonly HashSet<ulong> _usages;
1228     private readonly HashSet<ulong> _enter;
1229
1230     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1231     public AllUsagesIntersectingCollector(SynchronizedLinks<ulong> links, HashSet<ulong>
↪ 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
↪ right)
1257 {

```

```

1258     TryStepLeftUp(handler, left, right);
1259     TryStepRightUp(handler, right, left);
1260 }
1261
1262 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1263 private void AllCloseConnections(Action<IList<LinkIndex>> handler, ulong left, ulong
↪ right)
1264 {
1265     // Direct
1266     if (left == right)
1267     {
1268         handler(new LinkAddress<LinkIndex>(left));
1269     }
1270     var doublet = Links.Unsync.SearchOrDefault(left, right);
1271     if (doublet != Constants.Null)
1272     {
1273         handler(new LinkAddress<LinkIndex>(doublet));
1274     }
1275     // Inner
1276     CloseInnerConnections(handler, left, right);
1277     // Outer
1278     StepLeft(handler, left, right);
1279     StepRight(handler, left, right);
1280     PartialStepRight(handler, left, right);
1281     PartialStepLeft(handler, left, right);
1282 }
1283
1284 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1285 private HashSet<ulong> GetAllPartiallyMatchingSequencesCore(ulong[] sequence,
↪ HashSet<ulong> previousMatchings, long startAt)
1286 {
1287     if (startAt >= sequence.Length) // ?
1288     {
1289         return previousMatchings;
1290     }
1291     var secondLinkUsages = new HashSet<ulong>();
1292     AllUsagesCore(sequence[startAt], secondLinkUsages);
1293     secondLinkUsages.Add(sequence[startAt]);
1294     var matchings = new HashSet<ulong>();
1295     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,
↪ secondLinkUsage);
1302             StepRight(filler.AddFirstAndReturnConstant, previousMatching,
↪ secondLinkUsage);
1303             TryStepRightUp(filler.AddFirstAndReturnConstant, secondLinkUsage,
↪ previousMatching);
1304             //PartialStepRight(matchings.AddAndReturnVoid, secondLinkUsage,
↪ sequence[startAt]); // почему-то эта ошибочная запись приводит к
↪ желаемым результатам.
1305             PartialStepRight(filler.AddFirstAndReturnConstant, previousMatching,
↪ secondLinkUsage);
1306         }
1307     }
1308     if (matchings.Count == 0)
1309     {
1310         return matchings;
1311     }
1312     return GetAllPartiallyMatchingSequencesCore(sequence, matchings, startAt + 1); // ??
1313 }
1314
1315 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1316 private static void EnsureEachLinkIsAnyOrZeroOrManyOrExists(SynchronizedLinks<ulong>
↪ links, params ulong[] sequence)
1317 {
1318     if (sequence == null)
1319     {
1320         return;
1321     }
1322     for (var i = 0; i < sequence.Length; i++)
1323     {
1324         if (sequence[i] != links.Constants.Any && sequence[i] != ZeroOrMany &&
↪ !links.Exists(sequence[i]))

```

```

1325         {
1326             throw new ArgumentException<ulong>(sequence[i],
1327                 ↪ $"patternSequence[{i}]");
1328         }
1329     }
1330
1331     // Pattern Matching -> Key To Triggers
1332     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1333     public HashSet<ulong> MatchPattern(params ulong[] patternSequence)
1334     {
1335         return _sync.ExecuteReadOperation(() =>
1336         {
1337             patternSequence = Simplify(patternSequence);
1338             if (patternSequence.Length > 0)
1339             {
1340                 EnsureEachLinkIsAnyOrZeroOrManyOrExists(Links, patternSequence);
1341                 var uniqueSequenceElements = new HashSet<ulong>();
1342                 for (var i = 0; i < patternSequence.Length; i++)
1343                 {
1344                     if (patternSequence[i] != Constants.Any && patternSequence[i] !=
1345                         ↪ ZeroOrMany)
1346                     {
1347                         uniqueSequenceElements.Add(patternSequence[i]);
1348                     }
1349                 }
1350                 var results = new HashSet<ulong>();
1351                 foreach (var uniqueSequenceElement in uniqueSequenceElements)
1352                 {
1353                     AllUsagesCore(uniqueSequenceElement, results);
1354                 }
1355                 var filteredResults = new HashSet<ulong>();
1356                 var matcher = new PatternMatcher(this, patternSequence, filteredResults);
1357                 matcher.AddAllPatternMatchedToResults(results);
1358                 return filteredResults;
1359             }
1360             return new HashSet<ulong>();
1361         });
1362     }
1363
1364     // Найти все возможные связи между указанным списком связей.
1365     // Находит связи между всеми указанными связями в любом порядке.
1366     // TODO: решить что делать с повторами (когда одни и те же элементы встречаются
1367     ↪ несколько раз в последовательности)
1368     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1369     public HashSet<ulong> GetAllConnections(params ulong[] linksToConnect)
1370     {
1371         return _sync.ExecuteReadOperation(() =>
1372         {
1373             var results = new HashSet<ulong>();
1374             if (linksToConnect.Length > 0)
1375             {
1376                 Links.EnsureLinkExists(linksToConnect);
1377                 AllUsagesCore(linksToConnect[0], results);
1378                 for (var i = 1; i < linksToConnect.Length; i++)
1379                 {
1380                     var next = new HashSet<ulong>();
1381                     AllUsagesCore(linksToConnect[i], next);
1382                     results.IntersectWith(next);
1383                 }
1384             }
1385             return results;
1386         });
1387     }
1388
1389     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1390     public HashSet<ulong> GetAllConnections1(params ulong[] linksToConnect)
1391     {
1392         return _sync.ExecuteReadOperation(() =>
1393         {
1394             var results = new HashSet<ulong>();
1395             if (linksToConnect.Length > 0)
1396             {
1397                 Links.EnsureLinkExists(linksToConnect);
1398                 var collector1 = new AllUsagesCollector(Links.Unsync, results);
1399                 collector1.Collect(linksToConnect[0]);
1400                 var next = new HashSet<ulong>();
1401                 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 }
1461
1462 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1463 private static ulong[] Simplify(ulong[] sequence)
1464 {
1465     // Считаем новый размер последовательности
1466     long newLength = 0;
1467     var zeroOrManyStepped = false;
1468     for (var i = 0; i < sequence.Length; i++)
1469     {
1470         if (sequence[i] == ZeroOrMany)
1471         {
1472             if (zeroOrManyStepped)
1473             {
1474                 continue;
1475             }
1476             zeroOrManyStepped = true;
1477         }
1478     }

```



```

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
1523 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1524 public List<ulong> GetSimilarSequences() => new List<ulong>();
1525
1526 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1527 public void Prediction()
1528 {
1529     //_links
1530     //sequences
1531 }
1532
1533 #region From Triplets
1534
1535 //public static void DeleteSequence(Link sequence)
1536 //{
1537 //}
1538
1539 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1540 public List<ulong> CollectMatchingSequences(ulong[] links)
1541 {
1542     if (links.Length == 1)
1543     {
1544         throw new InvalidOperationException("Подпоследовательности с одним элементом не
1545         ↪ поддерживаются.");
1546     }
1547     var leftBound = 0;
1548     var rightBound = links.Length - 1;
1549     var left = links[leftBound++];
1550     var right = links[rightBound--];
1551     var results = new List<ulong>();
1552     CollectMatchingSequences(left, leftBound, links, right, rightBound, ref results);
1553     return results;
1554 }

```

```

1553 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1554 private void CollectMatchingSequences(ulong leftLink, int leftBound, ulong[]
1555     ↪ middleLinks, ulong rightLink, int rightBound, ref List<ulong> results)
1556 {
1557     var leftLinkTotalReferers = Links.Unsync.Count(leftLink);
1558     var rightLinkTotalReferers = Links.Unsync.Count(rightLink);
1559     if (leftLinkTotalReferers <= rightLinkTotalReferers)
1560     {
1561         var nextLeftLink = middleLinks[leftBound];
1562         var elements = GetRightElements(leftLink, nextLeftLink);
1563         if (leftBound <= rightBound)
1564         {
1565             for (var i = elements.Length - 1; i >= 0; i--)
1566             {
1567                 var element = elements[i];
1568                 if (element != 0)
1569                 {
1570                     CollectMatchingSequences(element, leftBound + 1, middleLinks,
1571                         ↪ rightLink, rightBound, ref results);
1572                 }
1573             }
1574         }
1575     }
1576     else
1577     {
1578         for (var i = elements.Length - 1; i >= 0; i--)
1579         {
1580             var element = elements[i];
1581             if (element != 0)
1582             {
1583                 results.Add(element);
1584             }
1585         }
1586     }
1587 }
1588 else
1589 {
1590     var nextRightLink = middleLinks[rightBound];
1591     var elements = GetLeftElements(rightLink, nextRightLink);
1592     if (leftBound <= rightBound)
1593     {
1594         for (var i = elements.Length - 1; i >= 0; i--)
1595         {
1596             var element = elements[i];
1597             if (element != 0)
1598             {
1599                 CollectMatchingSequences(leftLink, leftBound, middleLinks,
1600                     ↪ elements[i], rightBound - 1, ref results);
1601             }
1602         }
1603     }
1604     else
1605     {
1606         for (var i = elements.Length - 1; i >= 0; i--)
1607         {
1608             var element = elements[i];
1609             if (element != 0)
1610             {
1611                 results.Add(element);
1612             }
1613         }
1614     }
1615 }
1616 }
1617 }
1618 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1619 public ulong[] GetRightElements(ulong startLink, ulong rightLink)
1620 {
1621     var result = new ulong[5];
1622     TryStepRight(startLink, rightLink, result, 0);
1623     Links.Each(Constants.Any, startLink, couple =>
1624     {
1625         if (couple != startLink)
1626         {
1627             if (TryStepRight(couple, rightLink, result, 2))
1628             {
1629                 return false;
1630             }
1631         }
1632     }
1633 }

```

```

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             return true;
1665         }
1666     });
1667     return added > 0;
1668 }
1669
1670 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1671 public ulong[] GetLeftElements(ulong startLink, ulong leftLink)
1672 {
1673     var result = new ulong[5];
1674     TryStepLeft(startLink, leftLink, result, 0);
1675     Links.Each(startLink, Constants.Any, couple =>
1676     {
1677         if (couple != startLink)
1678         {
1679             if (TryStepLeft(couple, leftLink, result, 2))
1680             {
1681                 return false;
1682             }
1683             return true;
1684         }
1685     });
1686     if (Links.GetSource(Links.GetSource(leftLink)) == startLink)
1687     {
1688         result[4] = leftLink;
1689     }
1690     return result;
1691 }
1692
1693 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1694 public bool TryStepLeft(ulong startLink, ulong leftLink, ulong[] result, int offset)
1695 {
1696     var added = 0;
1697     Links.Each(Constants.Any, startLink, couple =>
1698     {
1699         if (couple != startLink)
1700         {
1701             var coupleSource = Links.GetSource(couple);
1702             if (coupleSource == leftLink)
1703             {
1704                 result[offset] = couple;
1705                 if (++added == 2)
1706                 {

```

```

1706         return false;
1707     }
1708 }
1709 else if (Links.GetTarget(coupleSource) == leftLink) // coupleSource.Linker
    ↳ == Net.And &&
1710 {
1711     result[offset + 1] = couple;
1712     if (++added == 2)
1713     {
1714         return false;
1715     }
1716 }
1717 }
1718 return true;
1719 });
1720 return added > 0;
1721 }
1722
1723 #endregion
1724
1725 #region Walkers
1726
1727 public class PatternMatcher : RightSequenceWalker<ulong>
1728 {
1729     private readonly Sequences _sequences;
1730     private readonly ulong[] _patternSequence;
1731     private readonly HashSet<LinkIndex> _linksInSequence;
1732     private readonly HashSet<LinkIndex> _results;
1733
1734     #region Pattern Match
1735
1736     enum PatternBlockType
1737     {
1738         Undefined,
1739         Gap,
1740         Elements
1741     }
1742
1743     struct PatternBlock
1744     {
1745         public PatternBlockType Type;
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     }

```

```

1782         return _patternPosition == _pattern.Count || (_patternPosition == _pattern.Count
1783             ↪ - 1 && _pattern[_patternPosition].Start == 0);
1784     }
1785     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1786     private List<PatternBlock> CreateDetailedPattern()
1787     {
1788         var pattern = new List<PatternBlock>();
1789         var patternBlock = new PatternBlock();
1790         for (var i = 0; i < _patternSequence.Length; i++)
1791         {
1792             if (patternBlock.Type == PatternBlockType.Undefined)
1793             {
1794                 if (_patternSequence[i] == _sequences.Constants.Any)
1795                 {
1796                     patternBlock.Type = PatternBlockType.Gap;
1797                     patternBlock.Start = 1;
1798                     patternBlock.Stop = 1;
1799                 }
1800                 else if (_patternSequence[i] == ZeroOrMany)
1801                 {
1802                     patternBlock.Type = PatternBlockType.Gap;
1803                     patternBlock.Start = 0;
1804                     patternBlock.Stop = long.MaxValue;
1805                 }
1806                 else
1807                 {
1808                     patternBlock.Type = PatternBlockType.Elements;
1809                     patternBlock.Start = i;
1810                     patternBlock.Stop = i;
1811                 }
1812             }
1813             else if (patternBlock.Type == PatternBlockType.Elements)
1814             {
1815                 if (_patternSequence[i] == _sequences.Constants.Any)
1816                 {
1817                     pattern.Add(patternBlock);
1818                     patternBlock = new PatternBlock
1819                     {
1820                         Type = PatternBlockType.Gap,
1821                         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 */
1902 //        if (matchhere(regexp, text))
1903 //            return 1;
1904 //    } while (*text != '\0' && (*text++ == c || c == '.'));
1905 //    return 0;
1906 //}
1907
1908 //private void GetNextPatternElement(out LinkIndex element, out long mininumGap, out
1909 ↪ long maximumGap)
1910 //{
1911 //    mininumGap = 0;
1912 //    maximumGap = 0;
1913 //    element = 0;
1914 //    for (; _patternPosition < _patternSequence.Length; _patternPosition++)
1915 //    {
1916 //        if (_patternSequence[_patternPosition] == Doublets.Links.Null)
1917 //            mininumGap++;
1918 //        else if (_patternSequence[_patternPosition] == ZeroOrMany)
1919 //            maximumGap = long.MaxValue;
1920 //        else
1921 //            break;
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     {

```

```

1937 //var currentMatchingBlockLength = (_sequencePosition -
    ↳ _lastMatchedBlockPosition);
1938 if (_sequencePosition < currentPatternBlock.Start)
1939 {
1940     _sequencePosition++;
1941     return true; // Двигаемся дальше
1942 }
1943 // Это последний блок
1944 if (_pattern.Count == _patternPosition + 1)
1945 {
1946     _patternPosition++;
1947     _sequencePosition = 0;
1948     return false; // Полное соответствие
1949 }
1950 else
1951 {
1952     if (_sequencePosition > currentPatternBlock.Stop)
1953     {
1954         return false; // Соответствие невозможно
1955     }
1956     var nextPatternBlock = _pattern[_patternPosition + 1];
1957     if (_patternSequence[nextPatternBlock.Start] == element)
1958     {
1959         if (nextPatternBlock.Start < nextPatternBlock.Stop)
1960         {
1961             _patternPosition++;
1962             _sequencePosition = 1;
1963         }
1964         else
1965         {
1966             _patternPosition += 2;
1967             _sequencePosition = 0;
1968         }
1969     }
1970 }
1971 }
1972 else // currentPatternBlock.Type == PatternBlockType.Elements
1973 {
1974     var patternElementPosition = currentPatternBlock.Start + _sequencePosition;
1975     if (_patternSequence[patternElementPosition] != element)
1976     {
1977         return false; // Соответствие невозможно
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 }

```

1.149 ./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     /// Можно убрать зависимость от конкретной реализации Links,
45     /// на зависимость от абстрактного элемента, который может быть представлен несколькими
46     ///     ↳ способами.
47     ///
48     /// Можно ли как-то сделать один общий интерфейс
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46  ///
47  /// Блокчейн и/или гит для распределённой записи транзакций.
48  ///
49  /// </remarks>
50  public partial class Sequences : ILinks<LinkIndex> // IList<string>, IList<LinkIndex[]>
    ↪ (после завершения реализации Sequences)
51  {
52      /// <summary>Возвращает значение LinkIndex, обозначающее любое количество
    ↪ связей.</summary>
53      public const LinkIndex ZeroOrMany = LinkIndex.MaxValue;
54
55      public SequencesOptions<LinkIndex> Options { get; }
56      public SynchronizedLinks<LinkIndex> Links { get; }
57      private readonly ISynchronization _sync;
58
59      public LinksConstants<LinkIndex> Constants { get; }
60
61      [MethodImpl(MethodImplOptions.AggressiveInlining)]
62      public Sequences(SynchronizedLinks<LinkIndex> links, SequencesOptions<LinkIndex> options)
63      {
64          Links = links;
65          _sync = links.SyncRoot;
66          Options = options;
67          Options.ValidateOptions();
68          Options.InitOptions(Links);
69          Constants = links.Constants;
70      }
71
72      [MethodImpl(MethodImplOptions.AggressiveInlining)]
73      public Sequences(SynchronizedLinks<LinkIndex> links) : this(links, new
    ↪ SequencesOptions<LinkIndex>()) { }
74
75      [MethodImpl(MethodImplOptions.AggressiveInlining)]
76      public bool IsSequence(LinkIndex sequence)
77      {
78          return _sync.ExecuteReadOperation(() =>
79          {
80              if (Options.UseSequenceMarker)
81              {
82                  return Options.MarkedSequenceMatcher.IsMatched(sequence);
83              }
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(IList<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) -
166                     ↪ 1;
167             }
168             return Links.Count(any, elementsLink);
169         }
170         return Links.Count(any, restrictions[0]);
171     }
172     throw new NotImplementedException();
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(IList<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<IList<LinkIndex>, LinkIndex> handler, IList<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,
↪ Options.SequenceMarkerLink, any));
256                 }
257                 else
258                 {
259                     return Links.Unsync.Each(handler, new Link<LinkIndex>(any, any,
↪ any));
260                 }
261             }
262             if (Options.UseSequenceMarker)
263             {
264                 var sequenceLinkValues = Links.Unsync.GetLink(link);
265                 if (sequenceLinkValues[Constants.SourcePart] ==
↪ Options.SequenceMarkerLink)
266                 {
267                     link = sequenceLinkValues[Constants.TargetPart];
268                 }
269             }
270             var sequence = Options.Walker.Walk(link).ToArray().ShiftRight();
271             sequence[0] = link;
272             return handler(sequence);
273         }

```

```

274     else if (restrictions.Count == 2)
275     {
276         throw new NotImplementedException();
277     }
278     else if (restrictions.Count == 3)
279     {
280         return Links.Unsync.Each(handler, restrictions);
281     }
282     else
283     {
284         var sequence = restrictions.SkipFirst();
285         if (Options.UseIndex && !Options.Index.MightContain(sequence))
286         {
287             return Constants.Break;
288         }
289         return EachCore(handler, sequence);
290     }
291 });
292 }
293
294 [MethodImpl(MethodImplOptions.AggressiveInlining)]
295 private LinkIndex EachCore(Func<IList<LinkIndex>, LinkIndex> handler, IList<LinkIndex>
    ↪ values)
296 {
297     var matcher = new Matcher(this, values, new HashSet<LinkIndex>(), handler);
298     // TODO: Find out why matcher.HandleFullMatched executed twice for the same sequence
    ↪ Id.
299     Func<IList<LinkIndex>, LinkIndex> innerHandler = Options.UseSequenceMarker ?
    ↪ (Func<IList<LinkIndex>, LinkIndex>)matcher.HandleFullMatchedSequence :
    ↪ matcher.HandleFullMatched;
300     //if (sequence.Length >= 2)
301     if (StepRight(innerHandler, values[0], values[1]) != Constants.Continue)
302     {
303         return Constants.Break;
304     }
305     var last = values.Count - 2;
306     for (var i = 1; i < last; i++)
307     {
308         if (PartialStepRight(innerHandler, values[i], values[i + 1]) !=
    ↪ Constants.Continue)
309         {
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         ClearGarbage(sequenceElementsContents.Source);
458         ClearGarbage(sequenceElementsContents.Target);
459     }
460     else
461     {
462         if (Options.UseSequenceMarker)
463         {
464             var sequenceElements = GetSequenceElements(sequence);
465             var sequenceLink = GetSequenceByElements(sequenceElements);
466             var newSequenceElements = GetSequenceElements(newSequence);
467             var newSequenceLink = GetSequenceByElements(newSequenceElements);
468             if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
469             {
470                 if (sequenceLink != Constants.Null)
471                 {
472                     Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
473                 }
474                 Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
475             }
476         }
477         else
478         {
479             if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
480             {
481                 Links.Unsync.MergeAndDelete(sequence, newSequence);
482             }
483         }
484     }
485 }
486
487 #endregion
488
489 #region Delete

```

```

487 [MethodImpl(MethodImplOptions.AggressiveInlining)]
488 public void Delete(ICollection<LinkIndex> restrictions)
489 {
490     _sync.ExecuteWriteOperation(() =>
491     {
492         var sequence = restrictions.SkipFirst();
493         // TODO: Check all options only ones before loop execution
494         foreach (var linkToDelete in Each(sequence))
495         {
496             DeleteOneCore(linkToDelete);
497         }
498     });
499 }
500
501 [MethodImpl(MethodImplOptions.AggressiveInlining)]
502 private void DeleteOneCore(LinkIndex link)
503 {
504     if (Options.UseGarbageCollection)
505     {
506         var sequenceElements = GetSequenceElements(link);
507         var sequenceElementsContents = new Link<ulong>(Links.GetLink(sequenceElements));
508         var sequenceLink = GetSequenceByElements(sequenceElements);
509         if (Options.UseCascadeDelete || CountUsages(link) == 0)
510         {
511             if (sequenceLink != Constants.Null)
512             {
513                 Links.Unsync.Delete(sequenceLink);
514             }
515             Links.Unsync.Delete(link);
516         }
517         ClearGarbage(sequenceElementsContents.Source);
518         ClearGarbage(sequenceElementsContents.Target);
519     }
520     else
521     {
522         if (Options.UseSequenceMarker)
523         {
524             var sequenceElements = GetSequenceElements(link);
525             var sequenceLink = GetSequenceByElements(sequenceElements);
526             if (Options.UseCascadeDelete || CountUsages(link) == 0)
527             {
528                 if (sequenceLink != Constants.Null)
529                 {
530                     Links.Unsync.Delete(sequenceLink);
531                 }
532                 Links.Unsync.Delete(link);
533             }
534         }
535         else
536         {
537             if (Options.UseCascadeDelete || CountUsages(link) == 0)
538             {
539                 Links.Unsync.Delete(link);
540             }
541         }
542     }
543 }
544
545 #endregion
546
547 #region Compactification
548
549 [MethodImpl(MethodImplOptions.AggressiveInlining)]
550 public void CompactAll()
551 {
552     _sync.ExecuteWriteOperation(() =>
553     {
554         var sequences = Each((LinkAddress<LinkIndex>)Constants.Any);
555         for (int i = 0; i < sequences.Count; i++)
556         {
557             var sequence = this.ToList(sequences[i]);
558             Compact(sequence.ShiftRight());
559         }
560     });
561 }
562
563 /// <remarks>
564

```

```

565 /// bestVariant можно выбирать по максимальному числу использований,
566 /// но сбалансированный 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(IList<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(IList<LinkIndex> sequence) => UpdateCore(sequence,
    ↪ sequence);
587
588 #endregion
589
590 #region Garbage Collection
591
592 /// <remarks>
593 /// TODO: Добавить дополнительный обработчик / событие CanBeDeleted которое можно
    ↪ определить извне или в унаследованном классе
594 /// </remarks>
595 [MethodImpl(MethodImplOptions.AggressiveInlining)]
596 private bool IsGarbage(LinkIndex link) => link != Options.SequenceMarkerLink &&
    ↪ !Links.Unsync.IsPartialPoint(link) && Links.Count(Constants.Any, link) == 0;
597
598 [MethodImpl(MethodImplOptions.AggressiveInlining)]
599 private void ClearGarbage(LinkIndex link)
600 {
601     if (IsGarbage(link))
602     {
603         var contents = new Link<ulong>(Links.GetLink(link));
604         Links.Unsync.Delete(link);
605         ClearGarbage(contents.Source);
606         ClearGarbage(contents.Target);
607     }
608 }
609
610 #endregion
611
612 #region Walkers
613
614 [MethodImpl(MethodImplOptions.AggressiveInlining)]
615 public bool EachPart(Func<LinkIndex, bool> handler, LinkIndex sequence)
616 {
617     return _sync.ExecuteReadOperation(() =>
618     {
619         var links = Links.Unsync;
620         foreach (var part in Options.Walker.Walk(sequence))
621         {
622             if (!handler(part))
623             {
624                 return false;
625             }
626         }
627         return true;
628     });
629 }
630
631 public class Matcher : RightSequenceWalker<LinkIndex>
632 {
633     private readonly Sequences _sequences;
634     private readonly IList<LinkIndex> _patternSequence;
635     private readonly HashSet<LinkIndex> _linksInSequence;
636     private readonly HashSet<LinkIndex> _results;
637     private readonly Func<IList<LinkIndex>, LinkIndex> _stopableHandler;
638     private readonly HashSet<LinkIndex> _readAsElements;
639     private int _filterPosition;
640
641     [MethodImpl(MethodImplOptions.AggressiveInlining)]

```



```

642 public Matcher(Sequences sequences, IList<LinkIndex> patternSequence,
↳ HashSet<LinkIndex> results, Func<IList<LinkIndex>, LinkIndex> stopableHandler,
↳ HashSet<LinkIndex> readAsElements = null)
643 : base(sequences.Links.Unsync, new DefaultStack<LinkIndex>())
644 {
645     _sequences = sequences;
646     _patternSequence = patternSequence;
647     _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
↳ _links.Constants.Any && x != ZeroOrMany));
648     _results = results;
649     _stopableHandler = stopableHandler;
650     _readAsElements = readAsElements;
651 }
652
653 [MethodImpl(MethodImplOptions.AggressiveInlining)]
654 protected override bool IsElement(LinkIndex link) => base.IsElement(link) ||
↳ (_readAsElements != null && _readAsElements.Contains(link)) ||
↳ _linksInSequence.Contains(link);
655
656 [MethodImpl(MethodImplOptions.AggressiveInlining)]
657 public bool FullMatch(LinkIndex sequenceToMatch)
658 {
659     _filterPosition = 0;
660     foreach (var part in Walk(sequenceToMatch))
661     {
662         if (!FullMatchCore(part))
663         {
664             break;
665         }
666     }
667     return _filterPosition == _patternSequence.Count;
668 }
669
670 [MethodImpl(MethodImplOptions.AggressiveInlining)]
671 private bool FullMatchCore(LinkIndex element)
672 {
673     if (_filterPosition == _patternSequence.Count)
674     {
675         _filterPosition = -2; // Длиннее чем нужно
676         return false;
677     }
678     if (_patternSequence[_filterPosition] != _links.Constants.Any
679     && element != _patternSequence[_filterPosition])
680     {
681         _filterPosition = -1;
682         return false; // Начинается/Продолжается иначе
683     }
684     _filterPosition++;
685     return true;
686 }
687
688 [MethodImpl(MethodImplOptions.AggressiveInlining)]
689 public void AddFullMatchedToResults(IList<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(IList<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(IList<LinkIndex> restrictions)
711 {
712     var sequenceToMatch = restrictions[_links.Constants.IndexPart];
713     var sequence = _sequences.GetSequenceByElements(sequenceToMatch);
714     if (sequence != _links.Constants.Null && FullMatch(sequenceToMatch) &&
↳ _results.Add(sequenceToMatch))

```

```

715     {
716         return _stopableHandler(new LinkAddress<LinkIndex>(sequence));
717     }
718     return _links.Constants.Continue;
719 }
720
721 /// <remarks>
722 /// TODO: Add support for LinksConstants.Any
723 /// </remarks>
724 [MethodImpl(MethodImplOptions.AggressiveInlining)]
725 public bool PartialMatch(LinkIndex sequenceToMatch)
726 {
727     _filterPosition = -1;
728     foreach (var part in Walk(sequenceToMatch))
729     {
730         if (!PartialMatchCore(part))
731         {
732             break;
733         }
734     }
735     return _filterPosition == _patternSequence.Count - 1;
736 }
737
738 [MethodImpl(MethodImplOptions.AggressiveInlining)]
739 private bool PartialMatchCore(LinkIndex element)
740 {
741     if (_filterPosition == (_patternSequence.Count - 1))
742     {
743         return false; // Нашлось
744     }
745     if (_filterPosition >= 0)
746     {
747         if (element == _patternSequence[_filterPosition + 1])
748         {
749             _filterPosition++;
750         }
751         else
752         {
753             _filterPosition = -1;
754         }
755     }
756     if (_filterPosition < 0)
757     {
758         if (element == _patternSequence[0])
759         {
760             _filterPosition = 0;
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 }

```

```

794     }
795 }
796 }
797
798 [MethodImpl(MethodImplOptions.AggressiveInlining)]
799 public void AddAllPartialMatchedToResultsAndReadAsElements(IEnumerable<LinkIndex>
    ↪ sequencesToMatch)
800 {
801     foreach (var sequenceToMatch in sequencesToMatch)
802     {
803         if (PartialMatch(sequenceToMatch))
804         {
805             _readAsElements.Add(sequenceToMatch);
806             _results.Add(sequenceToMatch);
807         }
808     }
809 }
810 }
811
812 #endregion
813 }
814 }

```

1.150 ./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 ILinks<TLink> sequences, IList<TLink[]>
            ↪ groupedSequence)
13         {
14             var finalSequence = new TLink[groupedSequence.Count];
15             for (var i = 0; i < finalSequence.Length; i++)
16             {
17                 var part = groupedSequence[i];
18                 finalSequence[i] = part.Length == 1 ? part[0] :
                    ↪ sequences.Create(part.ShiftRight());
19             }
20             return sequences.Create(finalSequence.ShiftRight());
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
                ↪ LinkAddress<TLink>(sequence));
29             return list;
30         }
31     }
32 }

```

1.151 ./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
        ↪ ILinks<TLink> must contain GetConstants function.

```

```

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

```

```

    set;
}

public IConverter<IList<TLink>, TLink> LinksToSequenceConverter
{
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    get;
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    set;
}

public ISequenceIndex<TLink> Index
{
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    get;
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    set;
}

public ISequenceWalker<TLink> Walker
{
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    get;
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    set;
}

public bool ReadFullSequence
{
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    get;
    [MethodImpl(MethodImplOptions.AggressiveInlining)]
    set;
}

// TODO: Реализовать компактификацию при чтении
//public bool EnforceSingleSequenceVersionOnRead { get; set; }
//public bool UseRequestMarker { get; set; }
//public bool StoreRequestResults { get; set; }

[MethodImpl(MethodImplOptions.AggressiveInlining)]
public void InitOptions(ISynchronizedLinks<TLink> links)
{
    if (UseSequenceMarker)
    {
        if (_equalityComparer.Equals(SequenceMarkerLink, links.Constants.Null))
        {
            SequenceMarkerLink = links.CreatePoint();
        }
        else
        {
            if (!links.Exists(SequenceMarkerLink))
            {
                var link = links.CreatePoint();
                if (!_equalityComparer.Equals(link, SequenceMarkerLink))
                {
                    throw new InvalidOperationException("Cannot recreate sequence marker
↪ link.");
                }
            }
        }
        if (MarkedSequenceMatcher == null)
        {
            MarkedSequenceMatcher = new MarkedSequenceCriterionMatcher<TLink>(links,
↪ SequenceMarkerLink);
        }
    }
    var balancedVariantConverter = new BalancedVariantConverter<TLink>(links);
    if (UseCompression)
    {
        if (LinksToSequenceConverter == null)
        {
            ICounter<TLink, TLink> totalSequenceSymbolFrequencyCounter;
            if (UseSequenceMarker)
            {
                totalSequenceSymbolFrequencyCounter = new
↪ TotalMarkedSequenceSymbolFrequencyCounter<TLink>(links,
↪ MarkedSequenceMatcher);
            }
        }
    }
}

```

```

174         else
175         {
176             totalSequenceSymbolFrequencyCounter = new
177                 ↪ TotalSequenceSymbolFrequencyCounter<TLink>(links);
178         }
179         var doubletFrequenciesCache = new LinkFrequenciesCache<TLink>(links,
180             ↪ totalSequenceSymbolFrequencyCounter);
181         var compressingConverter = new CompressingConverter<TLink>(links,
182             ↪ balancedVariantConverter, doubletFrequenciesCache);
183         LinksToSequenceConverter = compressingConverter;
184     }
185 }
186 else
187 {
188     if (LinksToSequenceConverter == null)
189     {
190         LinksToSequenceConverter = balancedVariantConverter;
191     }
192 }
193 if (UseIndex && Index == null)
194 {
195     Index = new SequenceIndex<TLink>(links);
196 }
197 if (Walker == null)
198 {
199     Walker = new RightSequenceWalker<TLink>(links, new DefaultStack<TLink>());
200 }
201 }
202 }
203 }
204 }
205 }
206 }
207 }
208 }
209 }

```

1.152 ./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 }

```

1.153 ./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 }

```

```

20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override TLink GetNextElementAfterPush(TLink element) =>
23         ↪ _links.GetTarget(element);
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     protected override IEnumerable<TLink> WalkContents(TLink element)
27     {
28         var links = _links;
29         var parts = links.GetLink(element);
30         var start = links.Constants.SourcePart;
31         for (var i = parts.Count - 1; i >= start; i--)
32         {
33             var part = parts[i];
34             if (IsElement(part))
35             {
36                 yield return part;
37             }
38         }
39     }
40 }

```

1.154 ./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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public LeveledSequenceWalker(ILinks<TLink> links) : base(links) => _isElement =
27             ↪ _links.IsPartialPoint;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public IEnumerable<TLink> Walk(TLink sequence) => ToArray(sequence);
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public TLink[] ToArray(TLink sequence)
34         {
35             var length = 1;
36             var array = new TLink[length];
37             array[0] = sequence;
38             if (_isElement(sequence))
39             {
40                 return array;
41             }
42             bool hasElements;
43             do
44             {
45                 length *= 2;
46 #if USEARRAYPOOL
47                 var nextArray = ArrayPool.Allocate<ulong>(length);
48 #else
49                 var nextArray = new TLink[length];
50 #endif
51                 hasElements = false;
52                 for (var i = 0; i < array.Length; i++)
53                 {
54                     var candidate = array[i];
55                     if (_equalityComparer.Equals(array[i], default))
56                     {

```

```

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 }

```

1.155 ./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 }

```

1.156 ./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

```

```

36         while (true)
37         {
38             if (IsElement(element))
39             {
40                 if (_stack.IsEmpty)
41                 {
42                     break;
43                 }
44                 element = _stack.Pop();
45                 foreach (var output in WalkContents(element))
46                 {
47                     yield return output;
48                 }
49                 element = GetNextElementAfterPop(element);
50             }
51             else
52             {
53                 _stack.Push(element);
54                 element = GetNextElementAfterPush(element);
55             }
56         }
57     }
58 }
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected virtual bool IsElement(TLink elementLink) => _isElement(elementLink);
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 protected abstract TLink GetNextElementAfterPop(TLink element);
65
66 [MethodImpl(MethodImplOptions.AggressiveInlining)]
67 protected abstract TLink GetNextElementAfterPush(TLink element);
68
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 protected abstract IEnumerable<TLink> WalkContents(TLink element);
71 }
72 }

```

1.157 ./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);

```

```

41         _links.Update(_stack, GetStackMarker(), previousTop);
42         _links.Delete(top);
43     }
44     return element;
45 }
46
47 [MethodImpl(MethodImplOptions.AggressiveInlining)]
48 public void Push(TLink element) => _links.Update(_stack, GetStackMarker(),
    ↪ _links.GetOrCreate(GetTop(), element));
49 }
50 }

```

1.158 ./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 }

```

1.159 ./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
    ↪ ReaderWriterLockSynchronization(), links) { }
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public SynchronizedLinks(ISynchronization synchronization, ILinks<TLinkAddress> links)
47         {

```

```

48     SyncRoot = synchronization;
49     Sync = this;
50     Unsync = links;
51     Constants = links.Constants;
52 }
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 public TLinkAddress Count(IList<TLinkAddress> restriction) =>
    ↳ SyncRoot.ExecuteReadOperation(restriction, Unsync.Count);
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 public TLinkAddress Each(Func<IList<TLinkAddress>, TLinkAddress> handler,
    ↳ IList<TLinkAddress> restrictions) => SyncRoot.ExecuteReadOperation(handler,
    ↳ restrictions, (handler1, restrictions1) => Unsync.Each(handler1, restrictions1));
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 public TLinkAddress Create(IList<TLinkAddress> restrictions) =>
    ↳ SyncRoot.ExecuteWriteOperation(restrictions, Unsync.Create);
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 public TLinkAddress Update(IList<TLinkAddress> restrictions, IList<TLinkAddress>
    ↳ substitution) => SyncRoot.ExecuteWriteOperation(restrictions, substitution,
    ↳ Unsync.Update);
65
66 [MethodImpl(MethodImplOptions.AggressiveInlining)]
67 public void Delete(IList<TLinkAddress> restrictions) =>
    ↳ SyncRoot.ExecuteWriteOperation(restrictions, Unsync.Delete);
68
69 //public T Trigger(IList<T> restriction, Func<IList<T>, IList<T>, T> matchedHandler,
    ↳ IList<T> substitution, Func<IList<T>, IList<T>, T> substitutedHandler)
70 //{
71 //    if (restriction != null && substitution != null &&
    ↳ !substitution.EqualTo(restriction))
72 //        return SyncRoot.ExecuteWriteOperation(restriction, matchedHandler,
    ↳ substitution, substitutedHandler, Unsync.Trigger);
73
74 //    return SyncRoot.ExecuteReadOperation(restriction, matchedHandler, substitution,
    ↳ substitutedHandler, Unsync.Trigger);
75 //}
76 }
77 }

```

1.160 ./csharp/Platform.Data.Doublets/Time/DateTimeToLongRawNumberSequenceConverter.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Converters;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Time
8  {
9      public class DateTimeToLongRawNumberSequenceConverter<TLink> : IConverter<DateTime, TLink>
10     {
11         private readonly IConverter<long, TLink> _int64ToLongRawNumberConverter;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public DateTimeToLongRawNumberSequenceConverter(IConverter<long, TLink>
            ↳ int64ToLongRawNumberConverter) => _int64ToLongRawNumberConverter =
            ↳ int64ToLongRawNumberConverter;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public TLink Convert(DateTime source) =>
            ↳ _int64ToLongRawNumberConverter.Convert(source.ToFileTimeUtc());
18     }
19 }

```

1.161 ./csharp/Platform.Data.Doublets/Time/LongRawNumberSequenceToDateTimeConverter.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Converters;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Time
8  {
9      public class LongRawNumberSequenceToDateTimeConverter<TLink> : IConverter<TLink, DateTime>
10     {
11         private readonly IConverter<TLink, long> _longRawNumberConverterToInt64;
12

```

```

13     [MethodImpl(MethodImplOptions.AggressiveInlining)]
14     public LongRawNumberSequenceToDateTimeConverter(ICConverter<TLink, long>
        ↳ longRawNumberConverterToInt64) => _longRawNumberConverterToInt64 =
        ↳ longRawNumberConverterToInt64;
15
16     [MethodImpl(MethodImplOptions.AggressiveInlining)]
17     public DateTime Convert(TLink source) =>
        ↳ DateTime.FromFileTimeUtc(_longRawNumberConverterToInt64.Convert(source));
18 }
19 }

```

1.162 ./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 =
            ↳ Default<LinksConstants<ulong>>.Instance;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public static void UseUnicode(this ILinks<ulong> links) => UnicodeMap.InitNew(links);
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public static bool AnyLinkIsAny(this ILinks<ulong> links, params ulong[] sequence)
21         {
22             if (sequence == null)
23             {
24                 return false;
25             }
26             var constants = links.Constants;
27             for (var i = 0; i < sequence.Length; i++)
28             {
29                 if (sequence[i] == constants.Any)
30                 {
31                     return true;
32                 }
33             }
34             return false;
35         }
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public static string FormatStructure(this ILinks<ulong> links, ulong linkIndex,
            ↳ Func<Link<ulong>, bool> isElement, bool renderIndex = false, bool renderDebug =
            ↳ false)
39         {
40             var sb = new StringBuilder();
41             var visited = new HashSet<ulong>();
42             links.AppendStructure(sb, visited, linkIndex, isElement, (innerSb, link) =>
                ↳ innerSb.Append(link.Index), renderIndex, renderDebug);
43             return sb.ToString();
44         }
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         public static string FormatStructure(this ILinks<ulong> links, ulong linkIndex,
            ↳ Func<Link<ulong>, bool> isElement, Action<StringBuilder, Link<ulong>> appendElement,
            ↳ bool renderIndex = false, bool renderDebug = false)
48         {
49             var sb = new StringBuilder();
50             var visited = new HashSet<ulong>();
51             links.AppendStructure(sb, visited, linkIndex, isElement, appendElement, renderIndex,
                ↳ renderDebug);
52             return sb.ToString();
53         }
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         public static void AppendStructure(this ILinks<ulong> links, StringBuilder sb,
            ↳ HashSet<ulong> visited, ulong linkIndex, Func<Link<ulong>, bool> isElement,
            ↳ Action<StringBuilder, Link<ulong>> appendElement, bool renderIndex = false, bool
            ↳ renderDebug = false)
57         {

```

```

58     if (sb == null)
59     {
60         throw new ArgumentNullException(nameof(sb));
61     }
62     if (linkIndex == Constants.Null || linkIndex == Constants.Any || linkIndex ==
    ↪ Constants.Itself)
63     {
64         return;
65     }
66     if (links.Exists(linkIndex))
67     {
68         if (visited.Add(linkIndex))
69         {
70             sb.Append('(');
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,
    ↪ appendElement, renderIndex);
91                 }
92             }
93             sb.Append(' ');
94             if (link.Target == link.Index)
95             {
96                 sb.Append(link.Index);
97             }
98             else
99             {
100                 var target = new Link<ulong>(links.GetLink(link.Target));
101                 if (isElement(target))
102                 {
103                     appendElement(sb, target);
104                 }
105                 else
106                 {
107                     links.AppendStructure(sb, visited, target.Index, isElement,
    ↪ appendElement, renderIndex);
108                 }
109             }
110             sb.Append(')');
111         }
112         else
113         {
114             if (renderDebug)
115             {
116                 sb.Append('*');
117             }
118             sb.Append(linkIndex);
119         }
120     }
121     else
122     {
123         if (renderDebug)
124         {
125             sb.Append('~');
126         }
127         sb.Append(linkIndex);
128     }
129 }
130 }
131 }

```

1.163 ./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         /// Или
42         ///
43         /// public struct TransitionHeader
44         /// {
45         ///     public ulong TransactionIdCombined;
46         ///     public ulong TimestampCombined;
47         ///
48         ///     public ulong TransactionId
49         ///     {
50         ///         get
51         ///         {
52         ///             return (ulong) mask & TransactionIdCombined;
53         ///         }
54         ///     }
55         ///
56         ///     public UniqueTimestamp Timestamp
57         ///     {
58         ///         get
59         ///         {
60         ///             return (UniqueTimestamp)mask & TransactionIdCombined;
61         ///         }
62         ///     }
63         ///
64         ///     public TransactionItemType Type
65         ///     {
66         ///         get
67         ///         {
68         ///             // Использовать по одному биту из TransactionId и Timestamp,
69         ///             // для значения в 2 бита, которое представляет тип операции
70         ///             throw new NotImplementedException();
71         ///         }
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
94         [MethodImpl(MethodImplOptions.AggressiveInlining)]
95         public Transition(UniqueTimestampFactory uniqueTimestampFactory, ulong
96             ↪ transactionId, Link<ulong> before, Link<ulong> after)
97         {
98             TransactionId = transactionId;
99             Before = before;
100            After = after;
101            Timestamp = uniqueTimestampFactory.Create();
102        }
103
104         [MethodImpl(MethodImplOptions.AggressiveInlining)]
105         public Transition(UniqueTimestampFactory uniqueTimestampFactory, ulong
106             ↪ transactionId, Link<ulong> before) : this(uniqueTimestampFactory, transactionId,
107             ↪ before, default) { }
108
109         [MethodImpl(MethodImplOptions.AggressiveInlining)]
110         public Transition(UniqueTimestampFactory uniqueTimestampFactory, ulong
111             ↪ transactionId) : this(uniqueTimestampFactory, transactionId, default, default) {
112             ↪ }
113
114         [MethodImpl(MethodImplOptions.AggressiveInlining)]
115         public override string ToString() => $"{Timestamp} {TransactionId}: {Before} =>
116             ↪ {After}";
117
118         [MethodImpl(MethodImplOptions.AggressiveInlining)]
119         public override bool Equals(object obj) => obj is Transition transition ?
120             ↪ Equals(transition) : false;
121
122         [MethodImpl(MethodImplOptions.AggressiveInlining)]
123         public override int GetHashCode() => (TransactionId, Before, After,
124             ↪ Timestamp).GetHashCode();
125
126         [MethodImpl(MethodImplOptions.AggressiveInlining)]
127         public bool Equals(Transition other) => TransactionId == other.TransactionId &&
128             ↪ Before == other.Before && After == other.After && Timestamp == other.Timestamp;
129
130         [MethodImpl(MethodImplOptions.AggressiveInlining)]
131         public static bool operator ==(Transition left, Transition right) =>
132             ↪ left.Equals(right);
133
134         [MethodImpl(MethodImplOptions.AggressiveInlining)]
135         public static bool operator !=(Transition left, Transition right) => !(left ==
136             ↪ right);
137     }
138
139     /// <remarks>
140     /// Другие варианты реализации транзакций (атомарности):
141     /// 1. Разделение хранения значения связи ((Source Target) или (Source Linker
142     ///     ↪ Target)) и индексов.
143     /// 2. Хранение трансформаций/операций в отдельном хранилище Links, но дополнительно
144     ///     ↪ потребуется решить вопрос
145     ///     со ссылками на внешние идентификаторы, или как-то иначе решить вопрос с
146     ///     ↪ пересечениями идентификаторов.
147     ///
148     /// Где хранить промежуточный список транзакций?
149     ///
150     /// В оперативной памяти:
151     /// Минусы:
152     /// 1. Может усложнить систему, если она будет функционировать самостоятельно,
153     ///     так как нужно отдельно выделять память под список трансформаций.
154     /// 2. Выделенной оперативной памяти может не хватить, в том случае,
155     ///     если транзакция использует слишком много трансформаций.
156     /// -> Можно использовать жёсткий диск для слишком длинных транзакций.

```



```

143     /// -> Максимальный размер списка трансформаций можно ограничить / задать
144     ///     ↪ константой.
145     /// 3. При подтверждении транзакции (Commit) все трансформации записываются разом
146     ///     ↪ создавая задержку.
147     /// На жёстком диске:
148     /// Минусы:
149     /// 1. Длительный отклик, на запись каждой трансформации.
150     /// 2. Лог транзакций дополнительно наполняется отменёнными транзакциями.
151     ///     -> Это может решаться упаковкой/исключением дублирующих операций.
152     ///     -> Также это может решаться тем, что короткие транзакции вообще
153     ///         не будут записываться в случае отката.
154     /// 3. Перед тем как выполнять отмену операций транзакции нужно дождаться пока все
155     ///     ↪ операции (трансформации)
156     ///         будут записаны в лог.
157     /// </remarks>
158     public class Transaction : DisposableBase
159     {
160         private readonly Queue<Transition> _transitions;
161         private readonly UInt64LinksTransactionsLayer _layer;
162         public bool IsCommitted { get; private set; }
163         public bool IsReverted { get; private set; }
164
165         [MethodImpl(MethodImplOptions.AggressiveInlining)]
166         public Transaction(UInt64LinksTransactionsLayer layer)
167         {
168             _layer = layer;
169             if (_layer._currentTransactionId != 0)
170             {
171                 throw new NotSupportedException("Nested transactions not supported.");
172             }
173             IsCommitted = false;
174             IsReverted = false;
175             _transitions = new Queue<Transition>();
176             SetCurrentTransaction(layer, this);
177         }
178
179         [MethodImpl(MethodImplOptions.AggressiveInlining)]
180         public void Commit()
181         {
182             EnsureTransactionAllowsWriteOperations(this);
183             while (_transitions.Count > 0)
184             {
185                 var transition = _transitions.Dequeue();
186                 _layer._transitions.Enqueue(transition);
187             }
188             _layer._lastCommittedTransactionId = _layer._currentTransactionId;
189             IsCommitted = true;
190         }
191
192         [MethodImpl(MethodImplOptions.AggressiveInlining)]
193         private void Revert()
194         {
195             EnsureTransactionAllowsWriteOperations(this);
196             var transitionsToRevert = new Transition[_transitions.Count];
197             _transitions.CopyTo(transitionsToRevert, 0);
198             for (var i = transitionsToRevert.Length - 1; i >= 0; i--)
199             {
200                 _layer.RevertTransition(transitionsToRevert[i]);
201             }
202             IsReverted = true;
203         }
204
205         [MethodImpl(MethodImplOptions.AggressiveInlining)]
206         public static void SetCurrentTransaction(UInt64LinksTransactionsLayer layer,
207             ↪ Transaction transaction)
208         {
209             layer._currentTransactionId = layer._lastCommittedTransactionId + 1;
210             layer._currentTransactionTransitions = transaction._transitions;
211             layer._currentTransaction = transaction;
212         }
213
214         [MethodImpl(MethodImplOptions.AggressiveInlining)]
215         public static void EnsureTransactionAllowsWriteOperations(Transaction transaction)
216         {
217             if (transaction.IsReverted)
218             {
219                 throw new InvalidOperationException("Transation is reverted.");
220             }
221         }
222     }

```

```

218     }
219     if (transaction.IsCommitted)
220     {
221         throw new InvalidOperationException("Transation is committed.");
222     }
223 }
224
225 [MethodImpl(MethodImplOptions.AggressiveInlining)]
226 protected override void Dispose(bool manual, bool wasDisposed)
227 {
228     if (!wasDisposed && _layer != null && !_layer.Disposable.IsDisposed)
229     {
230         if (!IsCommitted && !IsReverted)
231         {
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));

```

```

295         CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
296             ↳ default, createdLink));
297         return createdLinkIndex;
298     }
299
300     [MethodImpl(MethodImplOptions.AggressiveInlining)]
301     public override ulong Update(IList<ulong> restrictions, IList<ulong> substitution)
302     {
303         var linkIndex = restrictions[_constants.IndexPart];
304         var beforeLink = new Link<ulong>(_links.GetLink(linkIndex));
305         linkIndex = _links.Update(restrictions, substitution);
306         var afterLink = new Link<ulong>(_links.GetLink(linkIndex));
307         CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
308             ↳ beforeLink, afterLink));
309         return linkIndex;
310     }
311
312     [MethodImpl(MethodImplOptions.AggressiveInlining)]
313     public override void Delete(IList<ulong> restrictions)
314     {
315         var link = restrictions[_constants.IndexPart];
316         var deletedLink = new Link<ulong>(_links.GetLink(link));
317         _links.Delete(link);
318         CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
319             ↳ deletedLink, default));
320     }
321
322     [MethodImpl(MethodImplOptions.AggressiveInlining)]
323     private Queue<Transition> GetCurrentTransitions() => _currentTransactionTransitions ??
324         ↳ _transitions;
325
326     [MethodImpl(MethodImplOptions.AggressiveInlining)]
327     private void CommitTransition(Transition transition)
328     {
329         if (_currentTransaction != null)
330         {
331             Transaction.EnsureTransactionAllowsWriteOperations(_currentTransaction);
332         }
333         var transitions = GetCurrentTransitions();
334         transitions.Enqueue(transition);
335     }
336
337     [MethodImpl(MethodImplOptions.AggressiveInlining)]
338     private void RevertTransition(Transition transition)
339     {
340         if (transition.After.IsNull()) // Revert Deletion with Creation
341         {
342             _links.Create();
343         }
344         else if (transition.Before.IsNull()) // Revert Creation with Deletion
345         {
346             _links.Delete(transition.After.Index);
347         }
348         else // Revert Update
349         {
350             _links.Update(new[] { transition.After.Index, transition.Before.Source,
351                 ↳ transition.Before.Target });
352         }
353     }
354
355     [MethodImpl(MethodImplOptions.AggressiveInlining)]
356     private void ResetCurrentTransation()
357     {
358         _currentTransactionId = 0;
359         _currentTransactionTransitions = null;
360         _currentTransaction = null;
361     }
362
363     [MethodImpl(MethodImplOptions.AggressiveInlining)]
364     private void PushTransitions()
365     {
366         if (_log == null || _transitions == null)
367         {
368             return;
369         }
370         for (var i = 0; i < _transitions.Count; i++)
371         {
372             var transition = _transitions.Dequeue();

```

```

368         _log.Write(transition);
369         _lastCommittedTransition = transition;
370     }
371 }
372
373 [MethodImpl(MethodImplOptions.AggressiveInlining)]
374 private void TransitionsPusher()
375 {
376     while (!Disposable.IsDisposed && _transitionsPusher != null)
377     {
378         Thread.Sleep(DefaultPushDelay);
379         PushTransitions();
380     }
381 }
382
383 [MethodImpl(MethodImplOptions.AggressiveInlining)]
384 public Transaction BeginTransaction() => new Transaction(this);
385
386 [MethodImpl(MethodImplOptions.AggressiveInlining)]
387 private void DisposeTransitions()
388 {
389     try
390     {
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 }

```

1.164 ./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         {

```

```

18     _addressToNumberConverter = addressToNumberConverter;
19     _unicodeSymbolMarker = unicodeSymbolMarker;
20 }
21
22 [MethodImpl(MethodImplOptions.AggressiveInlining)]
23 public TLink Convert(char source)
24 {
25     var unaryNumber =
26         ↪ _addressToNumberConverter.Convert(_charToAddressConverter.Convert(source));
27     return _links.GetOrCreate(unaryNumber, _unicodeSymbolMarker);
28 }
29 }

```

1.165 ./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 }

```

1.166 ./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>
15             ↪ charToUnicodeSymbolConverter) => _charToUnicodeSymbolConverter =
16             ↪ charToUnicodeSymbolConverter;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public IList<TLink> Convert(string source)
20         {
21             var elements = new TLink[source.Length];
22             for (var i = 0; i < elements.Length; i++)
23             {
24                 elements[i] = _charToUnicodeSymbolConverter.Convert(source[i]);
25             }
26             return elements;
27         }
28     }
29 }
```

1.167 ./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     return sb.ToString();
100 }
101
102 [MethodImpl(MethodImplOptions.AggressiveInlining)]
103 public static ulong[] FromCharsToLinkArray(char[] chars) => FromCharsToLinkArray(chars,
104 ↪ chars.Length);
105
106 [MethodImpl(MethodImplOptions.AggressiveInlining)]
107 public static ulong[] FromCharsToLinkArray(char[] chars, int count)
108 {
109     // char array to ulong array
110     var linksSequence = new ulong[count];
111     for (var i = 0; i < count; i++)
112     {
113         linksSequence[i] = FromCharToLink(chars[i]);
114     }
115     return linksSequence;
116 }
117
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 public static ulong[] FromStringToLinkArray(string sequence)
120 {
121     // char array to ulong array
122     var linksSequence = new ulong[sequence.Length];
123     for (var i = 0; i < sequence.Length; i++)
124     {

```

```

123         linksSequence[i] = FromCharToLink(sequence[i]);
124     }
125     return linksSequence;
126 }
127
128 [MethodImpl(MethodImplOptions.AggressiveInlining)]
129 public static List<ulong[]> FromStringToLinkArrayGroups(string sequence)
130 {
131     var result = new List<ulong[]>();
132     var offset = 0;
133     while (offset < sequence.Length)
134     {
135         var currentCategory = CharUnicodeInfo.GetUnicodeCategory(sequence[offset]);
136         var relativeLength = 1;
137         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 }

```


199 }

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

```
1 using System;
2 using System.Runtime.CompilerServices;
3 using Platform.Interfaces;
4 using Platform.Converters;
5 using Platform.Data.Doublets.Sequences.Walkers;
6 using System.Text;
7
8 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Unicode
11 {
12     public class UnicodeSequenceToStringConverter<TLink> : LinksOperatorBase<TLink>,
13         ↪ IConverter<TLink, string>
14     {
15         private readonly ICriterionMatcher<TLink> _unicodeSequenceCriterionMatcher;
16         private readonly ISequenceWalker<TLink> _sequenceWalker;
17         private readonly IConverter<TLink, char> _unicodeSymbolToCharConverter;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public UnicodeSequenceToStringConverter(ILinks<TLink> links, ICriterionMatcher<TLink>
21             ↪ unicodeSequenceCriterionMatcher, ISequenceWalker<TLink> sequenceWalker,
22             ↪ IConverter<TLink, char> unicodeSymbolToCharConverter) : base(links)
23         {
24             _unicodeSequenceCriterionMatcher = unicodeSequenceCriterionMatcher;
25             _sequenceWalker = sequenceWalker;
26             _unicodeSymbolToCharConverter = unicodeSymbolToCharConverter;
27         }
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public string Convert(TLink source)
31         {
32             if (!_unicodeSequenceCriterionMatcher.IsMatched(source))
33             {
34                 throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
35                     ↪ not a unicode sequence.");
36             }
37             var sequence = _links.GetSource(source);
38             var sb = new StringBuilder();
39             foreach(var character in _sequenceWalker.Walk(sequence))
40             {
41                 sb.Append(_unicodeSymbolToCharConverter.Convert(character));
42             }
43             return sb.ToString();
44         }
45     }
46 }
```

1.169 ./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>,
11         ↪ IConverter<TLink, char>
12     {
13         private static readonly UncheckedConverter<TLink, char> _addressToCharConverter =
14             ↪ UncheckedConverter<TLink, char>.Default;
15
16         private readonly IConverter<TLink> _numberToAddressConverter;
17         private readonly ICriterionMatcher<TLink> _unicodeSymbolCriterionMatcher;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public UnicodeSymbolToCharConverter(ILinks<TLink> links, IConverter<TLink>
21             ↪ numberToAddressConverter, ICriterionMatcher<TLink> unicodeSymbolCriterionMatcher) :
22             ↪ base(links)
23         {
24             _numberToAddressConverter = numberToAddressConverter;
25             _unicodeSymbolCriterionMatcher = unicodeSymbolCriterionMatcher;
26         }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public char Convert(TLink source)
30         {
31             if (!_unicodeSymbolCriterionMatcher.IsMatched(source))
32             {
33                 throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
34                     ↪ not a unicode symbol.");
35             }
36             var symbol = _links.GetSource(source);
37             var sb = new StringBuilder();
38             foreach(var character in _symbolWalker.Walk(symbol))
39             {
40                 sb.Append(_addressToCharConverter.Convert(character));
41             }
42             return sb.ToString();
43         }
44     }
45 }
```

```

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 }

```

1.170 ./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>,
        ↳ IConverter<IList<TLink>, TLink>
11     {
12         private readonly ISequenceIndex<TLink> _index;
13         private readonly IConverter<IList<TLink>, TLink> _listToSequenceLinkConverter;
14         private readonly TLink _unicodeSequenceMarker;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public UnicodeSymbolsListToUnicodeSequenceConverter(ILinks<TLink> links,
            ↳ ISequenceIndex<TLink> index, IConverter<IList<TLink>, TLink>
            ↳ listToSequenceLinkConverter, TLink unicodeSequenceMarker) : base(links)
18         {
19             _index = index;
20             _listToSequenceLinkConverter = listToSequenceLinkConverter;
21             _unicodeSequenceMarker = unicodeSequenceMarker;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public UnicodeSymbolsListToUnicodeSequenceConverter(ILinks<TLink> links,
            ↳ IConverter<IList<TLink>, TLink> listToSequenceLinkConverter, TLink
            ↳ unicodeSequenceMarker)
26             : this(links, new Unindex<TLink>(), listToSequenceLinkConverter,
            ↳ unicodeSequenceMarker) { }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public TLink Convert(IList<TLink> list)
30         {
31             _index.Add(list);
32             var sequence = _listToSequenceLinkConverter.Convert(list);
33             return _links.GetOrCreate(sequence, _unicodeSequenceMarker);
34         }
35     }
36 }

```

1.171 ./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().Test
37             ↪ stMultipleRandomCreationsAndDeletions(100));
38         Using<uint>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
39             ↪ MultipleRandomCreationsAndDeletions(100));
40         Using<ulong>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
41             ↪ tMultipleRandomCreationsAndDeletions(100));
42     }
43
44     private static void Using<TLink>(Action<ILinks<TLink>> action)
45     {
46         using (var scope = new Scope<Types<HeapResizableDirectMemory,
47             ↪ UnitedMemoryLinks<TLink>>>())
48         {
49             action(scope.Use<ILinks<TLink>>());
50         }
51     }
52 }

```

1.172 ./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 }

```

1.173 ./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),
11                 ↪ (long.MaxValue + 1UL, ulong.MaxValue));
12
13             //var minimum = new Hybrid<ulong>(0, isExternal: true);
14             var minimum = new Hybrid<ulong>(1, isExternal: true);
15             var maximum = new Hybrid<ulong>(long.MaxValue, isExternal: true);
16
17             Assert.True(constants.IsExternalReference(minimum));
18             Assert.True(constants.IsExternalReference(maximum));
19         }
20     }
21 }

```

1.174 ./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.Doublets.Memory;
21
22 namespace Platform.Data.Doublets.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);
101         var frequencyPropertyOperator = new PropertyOperator<ulong>(links,
102             ↪ frequencyPropertyMarker, frequencyMarker);
103         var index = new FrequencyIncrementingSequenceIndex<ulong>(links,
104             ↪ frequencyPropertyOperator, frequencyIncrementer);
105         var linkToItsFrequencyNumberConverter = new
106             ↪ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
107             ↪ unaryNumberToAddressConverter);
108         var sequenceToItsLocalElementLevelsConverter = new
109             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
110             ↪ linkToItsFrequencyNumberConverter);
111         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
112             ↪ sequenceToItsLocalElementLevelsConverter);
113
114         var sequences = new Sequences.Sequences(links, new SequencesOptions<ulong>() {
115             ↪ Walker = new LeveledSequenceWalker<ulong>(links) });
116
117         ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
118             ↪ index, optimalVariantConverter);
119     }
120 }
121
122 [Fact]
123 public static void DictionaryBasedFrequencyStoredOptimalVariantSequenceTest()
124 {
125     using (var scope = new TempLinksTestScope(useSequences: false))
126     {
127         var links = scope.Links;
128
129         links.UseUnicode();
130
131         var sequence = UnicodeMap.FromStringToLinkArray(_sequenceExample);
132
133         var totalSequenceSymbolFrequencyCounter = new
134             ↪ TotalSequenceSymbolFrequencyCounter<ulong>(links);
135
136         var linkFrequenciesCache = new LinkFrequenciesCache<ulong>(links,
137             ↪ totalSequenceSymbolFrequencyCounter);
138
139         var index = new
140             ↪ CachedFrequencyIncrementingSequenceIndex<ulong>(linkFrequenciesCache);
141         var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache);
142
143         var sequenceToItsLocalElementLevelsConverter = new
144             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
145             ↪ linkToItsFrequencyNumberConverter);
146         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
147             ↪ sequenceToItsLocalElementLevelsConverter);
148
149         var sequences = new Sequences.Sequences(links, new SequencesOptions<ulong>() {
150             ↪ Walker = new LeveledSequenceWalker<ulong>(links) });
151
152         ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
153             ↪ index, optimalVariantConverter);
154     }
155 }
156

```

```

137 private static void ExecuteTest(Sequences.Sequences sequences, ulong[] sequence,
    ↳ SequenceToItsLocalElementLevelsConverter<ulong>
    ↳ sequenceToItsLocalElementLevelsConverter, ISequenceIndex<ulong> index,
    ↳ OptimalVariantConverter<ulong> optimalVariantConverter)
138 {
139     index.Add(sequence);
140
141     var optimalVariant = optimalVariantConverter.Convert(sequence);
142
143     var readSequence1 = sequences.ToList(optimalVariant);
144
145     Assert.True(sequence.SequenceEqual(readSequence1));
146 }
147
148 [Fact]
149 public static void SavedSequencesOptimizationTest()
150 {
151     LinksConstants<ulong> constants = new LinksConstants<ulong>((1, long.MaxValue),
    ↳ (long.MaxValue + 1UL, ulong.MaxValue));
152
153     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 }

```

1.175 ./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

```

```

61     }
62 }
63 }

```

1.176 ./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<ulong> _constants =
12             ↳ Default<LinksConstants<ulong>>.Instance;
13
14         [Fact]
15         public static void BasicFileMappedMemoryTest()
16         {
17             var tempFilename = Path.GetTempFileName();
18             using (var memoryAdapter = new UInt64UnitedMemoryLinks(tempFilename))
19             {
20                 memoryAdapter.TestBasicMemoryOperations();
21             }
22             File.Delete(tempFilename);
23         }
24
25         [Fact]
26         public static void BasicHeapMemoryTest()
27         {
28             using (var memory = new
29                 ↳ HeapResizableDirectMemory(UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
30             using (var memoryAdapter = new UInt64UnitedMemoryLinks(memory,
31                 ↳ UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
32             {
33                 memoryAdapter.TestBasicMemoryOperations();
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         }
69     }
70 }

```

1.177 ./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(Skip = "Would be fixed later.")]
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     }

```

1.178 ./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     }

```

```

23 static SequencesTests()
24 {
25     // Trigger static constructor to not mess with performance measurements
26     _ = BitString.GetBitMaskFromIndex(1);
27 }
28
29 [Fact]
30 public static void CreateAllVariantsTest()
31 {
32     const long sequenceLength = 8;
33
34     using (var scope = new TempLinksTestScope(useSequences: true))
35     {
36         var links = scope.Links;
37         var sequences = scope.Sequences;
38
39         var sequence = new ulong[sequenceLength];
40         for (var i = 0; i < sequenceLength; i++)
41         {
42             sequence[i] = links.Create();
43         }
44
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 [Fact]
103 public static void AllVariantsSearchTest()
104 {
105     const long sequenceLength = 8;
106
107     using (var scope = new TempLinksTestScope(useSequences: true))
108     {
109         var links = scope.Links;
110         var sequences = scope.Sequences;
111
112         var sequence = new ulong[sequenceLength];
113         for (var i = 0; i < sequenceLength; i++)
114         {
115             sequence[i] = links.Create();
116         }
117
118         var createResults = sequences.CreateAllVariants2(sequence).Distinct().ToArray();
119
120         //for (int i = 0; i < createResults.Length; i++)
121         //    sequences.Create(createResults[i]);
122
123         var sw0 = Stopwatch.StartNew();
124         var searchResults0 = sequences.GetAllMatchingSequences0(sequence); sw0.Stop();
125
126         var sw1 = Stopwatch.StartNew();
127         var searchResults1 = sequences.GetAllMatchingSequences1(sequence); sw1.Stop();
128
129         var sw2 = Stopwatch.StartNew();
130         var searchResults2 = sequences.Each1(sequence); sw2.Stop();
131
132         var sw3 = Stopwatch.StartNew();
133         var searchResults3 = sequences.Each(sequence.ShiftRight()); sw3.Stop();
134
135         var intersection0 = createResults.Intersect(searchResults0).ToList();
136         Assert.True(intersection0.Count == searchResults0.Count);
137         Assert.True(intersection0.Count == createResults.Length);
138
139         var intersection1 = createResults.Intersect(searchResults1).ToList();
140         Assert.True(intersection1.Count == searchResults1.Count);
141         Assert.True(intersection1.Count == createResults.Length);
142
143         var intersection2 = createResults.Intersect(searchResults2).ToList();
144         Assert.True(intersection2.Count == searchResults2.Count);
145         Assert.True(intersection2.Count == createResults.Length);
146
147         var intersection3 = createResults.Intersect(searchResults3).ToList();
148         Assert.True(intersection3.Count == searchResults3.Count);
149         Assert.True(intersection3.Count == createResults.Length);
150
151         for (var i = 0; i < sequenceLength; i++)
152         {
153             links.Delete(sequence[i]);
154         }
155     }
156 }
157
158 [Fact]
159 public static void BalancedVariantSearchTest()
160 {
161     const long sequenceLength = 200;
162
163     using (var scope = new TempLinksTestScope(useSequences: true))
164     {
165         var links = scope.Links;
166         var sequences = scope.Sequences;
167
168         var sequence = new ulong[sequenceLength];
169         for (var i = 0; i < sequenceLength; i++)
170         {
171             sequence[i] = links.Create();
172         }
173
174         var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
175
176         var sw1 = Stopwatch.StartNew();
177         var balancedVariant = balancedVariantConverter.Convert(sequence); sw1.Stop();
178
179         var sw2 = Stopwatch.StartNew();
180         var searchResults2 = sequences.GetAllMatchingSequences0(sequence); sw2.Stop();
181

```

```

182     var sw3 = Stopwatch.StartNew();
183     var searchResults3 = sequences.GetAllMatchingSequences1(sequence); sw3.Stop();
184
185     // На количестве в 200 элементов это будет занимать вечность
186     //var sw4 = Stopwatch.StartNew();
187     //var searchResults4 = sequences.Each(sequence); sw4.Stop();
188
189     Assert.True(searchResults2.Count == 1 && balancedVariant == searchResults2[0]);
190
191     Assert.True(searchResults3.Count == 1 && balancedVariant ==
192         ↪ searchResults3.First());
193
194     //Assert.True(sw1.Elapsed < sw2.Elapsed);
195
196     for (var i = 0; i < sequenceLength; i++)
197     {
198         links.Delete(sequence[i]);
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++)

```

```

254         {
255             links.Delete(sequence[i]);
256         }
257     }
258 }
259
260 [Fact]
261 public static void BalancedPartialVariantsSearchTest()
262 {
263     const long sequenceLength = 200;
264
265     using (var scope = new TempLinksTestScope(useSequences: true))
266     {
267         var links = scope.Links;
268         var sequences = scope.Sequences;
269
270         var sequence = new ulong[sequenceLength];
271         for (var i = 0; i < sequenceLength; i++)
272         {
273             sequence[i] = links.Create();
274         }
275
276         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         Assert.True(searchResults2.Count == 1 && balancedVariant ==
293             ↪ searchResults2.First());
294
295         for (var i = 0; i < sequenceLength; i++)
296         {
297             links.Delete(sequence[i]);
298         }
299     }
300 }
301
302 [Fact(Skip = "Correct implementation is pending")]
303 public static void PatternMatchTest()
304 {
305     var zeroOrMany = Sequences.Sequences.ZeroOrMany;
306
307     using (var scope = new TempLinksTestScope(useSequences: true))
308     {
309         var links = scope.Links;
310         var sequences = scope.Sequences;
311
312         var e1 = links.Create();
313         var e2 = links.Create();
314
315         var sequence = new[]
316         {
317             e1, e2, e1, e2 // mama / papa
318         };
319
320         var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
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     Assert.True(matchedSequences1.Count == 0);
332
333     var matchedSequences2 = sequences.MatchPattern(zeroOrMany, e2, e1);
334
335     Assert.True(matchedSequences2.Count == 0);
336
337     var matchedSequences3 = sequences.MatchPattern(e1, zeroOrMany, e1);
338
339     Assert.True(matchedSequences3.Count == 0);
340
341     var matchedSequences4 = sequences.MatchPattern(e1, zeroOrMany, e2);
342
343     Assert.Contains(douplet, matchedSequences4);
344     Assert.Contains(balancedVariant, matchedSequences4);
345
346     for (var i = 0; i < sequence.Length; i++)
347     {
348         links.Delete(sequence[i]);
349     }
350 }
351 }
352 }
353
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))
382
383

```

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

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

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

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

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

393 [![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)

394

395 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?

396

397 [![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)

398

399 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?

400

401 [![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-animat
↳      ion-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
↳                  TotalSequenceSymbolFrequencyCounter<ulong>(links.Unsync);
457              var doubletFrequenciesCache = new LinkFrequenciesCache<ulong>(links.Unsync,
↳                  totalSequenceSymbolFrequencyCounter);
458              var compressingConverter = new CompressingConverter<ulong>(links.Unsync,
↳                  balancedVariantConverter, doubletFrequenciesCache);
459
460              var compressedVariant = compressingConverter.Convert(sequence);
461
462              // 1: [1]          (1->1) point
463              // 2: [2]          (2->2) point
464              // 3: [1,2]        (1->2) doublet
465              // 4: [1,2,1,2]    (3->3) doublet
466
467              Assert.True(links.GetSource(links.GetSource(compressedVariant)) == sequence[0]);
468              Assert.True(links.GetTarget(links.GetSource(compressedVariant)) == sequence[1]);
469              Assert.True(links.GetSource(links.GetTarget(compressedVariant)) == sequence[2]);
470              Assert.True(links.GetTarget(links.GetTarget(compressedVariant)) == sequence[3]);
471
472              var source = _constants.SourcePart;
473              var target = _constants.TargetPart;
474
475              Assert.True(links.GetByKeys(compressedVariant, source, source) == sequence[0]);
476              Assert.True(links.GetByKeys(compressedVariant, source, target) == sequence[1]);
477              Assert.True(links.GetByKeys(compressedVariant, target, source) == sequence[2]);
478              Assert.True(links.GetByKeys(compressedVariant, target, target) == sequence[3]);
479
480              // 4 - length of sequence
481              Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 0)
↳                  == sequence[0]);
482              Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 1)
↳                  == sequence[1]);

```



```

483     Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 2)
484         ↪ == sequence[2]);
485     Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 3)
486         ↪ == sequence[3]);
487 }
488 [Fact]
489 public static void CompressionEfficiencyTest()
490 {
491     var strings = _exampleLoremIpsumText.Split(new[] { '\n', '\r' },
492         ↪ StringSplitOptions.RemoveEmptyEntries);
493     var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
494     var totalCharacters = arrays.Select(x => x.Length).Sum();
495
496     using (var scope1 = new TempLinksTestScope(useSequences: true))
497     using (var scope2 = new TempLinksTestScope(useSequences: true))
498     using (var scope3 = new TempLinksTestScope(useSequences: true))
499     {
500         scope1.Links.Unsync.UseUnicode();
501         scope2.Links.Unsync.UseUnicode();
502         scope3.Links.Unsync.UseUnicode();
503
504         var balancedVariantConverter1 = new
505             ↪ BalancedVariantConverter<ulong>(scope1.Links.Unsync);
506         var totalSequenceSymbolFrequencyCounter = new
507             ↪ TotalSequenceSymbolFrequencyCounter<ulong>(scope1.Links.Unsync);
508         var linkFrequenciesCache1 = new LinkFrequenciesCache<ulong>(scope1.Links.Unsync,
509             ↪ totalSequenceSymbolFrequencyCounter);
510         var compressor1 = new CompressingConverter<ulong>(scope1.Links.Unsync,
511             ↪ balancedVariantConverter1, linkFrequenciesCache1,
512             ↪ doInitialFrequenciesIncrement: false);
513
514         //var compressor2 = scope2.Sequences;
515         var compressor3 = scope3.Sequences;
516
517         var constants = Default<LinksConstants<ulong>>.Instance;
518
519         var sequences = compressor3;
520         //var meaningRoot = links.CreatePoint();
521         //var unaryOne = links.CreateAndUpdate(meaningRoot, constants.Itself);
522         //var frequencyMarker = links.CreateAndUpdate(meaningRoot, constants.Itself);
523         //var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot,
524             ↪ constants.Itself);
525
526         //var unaryNumberToAddressConverter = new
527             ↪ UnaryNumberToAddressAddOperationConverter<ulong>(links, unaryOne);
528         //var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links,
529             ↪ unaryOne);
530         //var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
531             ↪ frequencyMarker, unaryOne, unaryNumberIncrementer);
532         //var frequencyPropertyOperator = new FrequencyPropertyOperator<ulong>(links,
533             ↪ frequencyPropertyMarker, frequencyMarker);
534         //var linkFrequencyIncrementer = new LinkFrequencyIncrementer<ulong>(links,
535             ↪ frequencyPropertyOperator, frequencyIncrementer);
536         //var linkToItsFrequencyNumberConverter = new
537             ↪ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
538             ↪ unaryNumberToAddressConverter);
539
540         var linkFrequenciesCache3 = new LinkFrequenciesCache<ulong>(scope3.Links.Unsync,
541             ↪ totalSequenceSymbolFrequencyCounter);
542
543         var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache3);
544
545         var sequenceToItsLocalElementLevelsConverter = new
546             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(scope3.Links.Unsync,
547             ↪ linkToItsFrequencyNumberConverter);
548         var optimalVariantConverter = new
549             ↪ OptimalVariantConverter<ulong>(scope3.Links.Unsync,
550             ↪ sequenceToItsLocalElementLevelsConverter);
551
552         var compressed1 = new ulong[arrays.Length];
553         var compressed2 = new ulong[arrays.Length];
554         var compressed3 = new ulong[arrays.Length];
555
556         var START = 0;
557         var END = arrays.Length;
558

```

```

539
540 //for (int i = START; i < END; i++)
541 //    linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
542
543 var initialCount1 = scope2.Links.Unsync.Count();
544
545 var sw1 = Stopwatch.StartNew();
546
547 for (int i = START; i < END; i++)
548 {
549     linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
550     compressed1[i] = compressor1.Convert(arrays[i]);
551 }
552
553 var elapsed1 = sw1.Elapsed;
554
555 var balancedVariantConverter2 = new
556     ↳ BalancedVariantConverter<ulong>(scope2.Links.Unsync);
557
558 var initialCount2 = scope2.Links.Unsync.Count();
559
560 var sw2 = Stopwatch.StartNew();
561
562 for (int i = START; i < END; i++)
563 {
564     compressed2[i] = balancedVariantConverter2.Convert(arrays[i]);
565 }
566
567 var elapsed2 = sw2.Elapsed;
568
569 for (int i = START; i < END; i++)
570 {
571     linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
572 }
573
574 var initialCount3 = scope3.Links.Unsync.Count();
575
576 var sw3 = Stopwatch.StartNew();
577
578 for (int i = START; i < END; i++)
579 {
580     //linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
581     compressed3[i] = optimalVariantConverter.Convert(arrays[i]);
582 }
583
584 var elapsed3 = sw3.Elapsed;
585
586 Console.WriteLine($"Compressor: {elapsed1}, Balanced variant: {elapsed2},
587     ↳ Optimal variant: {elapsed3}");
588
589 // Assert.True(elapsed1 > elapsed2);
590
591 // Checks
592 for (int i = START; i < END; i++)
593 {
594     var sequence1 = compressed1[i];
595     var sequence2 = compressed2[i];
596     var sequence3 = compressed3[i];
597
598     var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
599         ↳ scope1.Links.Unsync);
600
601     var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
602         ↳ scope2.Links.Unsync);
603
604     var decompress3 = UnicodeMap.FromSequenceLinkToString(sequence3,
605         ↳ scope3.Links.Unsync);
606
607     var structure1 = scope1.Links.Unsync.FormatStructure(sequence1, link =>
608         ↳ link.IsPartialPoint());
609     var structure2 = scope2.Links.Unsync.FormatStructure(sequence2, link =>
610         ↳ link.IsPartialPoint());
611     var structure3 = scope3.Links.Unsync.FormatStructure(sequence3, link =>
612         ↳ link.IsPartialPoint());
613
614     //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
615         ↳ arrays[i].Length > 3)
616         //    Assert.False(structure1 == structure2);

```

```

608         //if (sequence3 != Constants.Null && sequence2 != Constants.Null &&
        ↪     arrays[i].Length > 3)
609         //    Assert.False(structure3 == structure2);
610
611         Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
612         Assert.True(strings[i] == decompress3 && decompress3 == decompress2);
613     }
614
615     Assert.True((int)(scope1.Links.Unsync.Count() - initialCount1) <
        ↪     totalCharacters);
616     Assert.True((int)(scope2.Links.Unsync.Count() - initialCount2) <
        ↪     totalCharacters);
617     Assert.True((int)(scope3.Links.Unsync.Count() - initialCount3) <
        ↪     totalCharacters);
618
619     Console.WriteLine($"{(double)(scope1.Links.Unsync.Count() - initialCount1) /
        ↪     totalCharacters} | {(double)(scope2.Links.Unsync.Count() - initialCount2) /
        ↪     totalCharacters} | {(double)(scope3.Links.Unsync.Count() - initialCount3) /
        ↪     totalCharacters}");
620
621     Assert.True(scope1.Links.Unsync.Count() - initialCount1 <
        ↪     scope2.Links.Unsync.Count() - initialCount2);
622     Assert.True(scope3.Links.Unsync.Count() - initialCount3 <
        ↪     scope2.Links.Unsync.Count() - initialCount2);
623
624     var duplicateProvider1 = new
        ↪     DuplicateSegmentsProvider<ulong>(scope1.Links.Unsync, scope1.Sequences);
625     var duplicateProvider2 = new
        ↪     DuplicateSegmentsProvider<ulong>(scope2.Links.Unsync, scope2.Sequences);
626     var duplicateProvider3 = new
        ↪     DuplicateSegmentsProvider<ulong>(scope3.Links.Unsync, scope3.Sequences);
627
628     var duplicateCounter1 = new DuplicateSegmentsCounter<ulong>(duplicateProvider1);
629     var duplicateCounter2 = new DuplicateSegmentsCounter<ulong>(duplicateProvider2);
630     var duplicateCounter3 = new DuplicateSegmentsCounter<ulong>(duplicateProvider3);
631
632     var duplicates1 = duplicateCounter1.Count();
633
634     ConsoleHelpers.Debug("-----");
635
636     var duplicates2 = duplicateCounter2.Count();
637
638     ConsoleHelpers.Debug("-----");
639
640     var duplicates3 = duplicateCounter3.Count();
641
642     Console.WriteLine($"{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))
        {

```

```

672 scope1.Links.UseUnicode();
673 scope2.Links.UseUnicode();
674
675 //var compressor1 = new Compressor(scope1.Links.Unsync, scope1.Sequences);
676 var compressor1 = scope1.Sequences;
677 var compressor2 = scope2.Sequences;
678
679 var compressed1 = new ulong[arrays.Length];
680 var compressed2 = new ulong[arrays.Length];
681
682 var sw1 = Stopwatch.StartNew();
683
684 var START = 0;
685 var END = arrays.Length;
686
687 // Collisions proved (cannot be solved by max doublet comparison, no stable rule)
688 // Stability issue starts at 10001 or 11000
689 //for (int i = START; i < END; i++)
690 //{
691 //    var first = compressor1.Compress(arrays[i]);
692 //    var second = compressor1.Compress(arrays[i]);
693
694 //    if (first == second)
695 //        compressed1[i] = first;
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);

```

```

750         var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
751             ↳ scope2.Links);
752
753         //var structure1 = scope1.Links.FormatStructure(sequence1, link =>
754             ↳ link.IsPartialPoint());
755         //var structure2 = scope2.Links.FormatStructure(sequence2, link =>
756             ↳ link.IsPartialPoint());
757
758         //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
759             ↳ arrays[i].Length > 3)
760         //    Assert.False(structure1 == structure2);
761
762         Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
763     }
764 }
765
766 Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
767 Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
768
769 Debug.WriteLine($"{(double)(scope1.Links.Count() - UnicodeMap.MapSize) /
770     ↳ totalCharacters} | {(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
771     ↳ totalCharacters}");
772
773 Assert.True(scope1.Links.Count() <= scope2.Links.Count());
774
775 //compressor1.ValidateFrequencies();
776 }
777 }
778
779 [Fact]
780 public static void RandomNumbersCompressionQualityTest()
781 {
782     const ulong N = 500;
783
784     //const ulong minNumbers = 10000;
785     //const ulong maxNumbers = 20000;
786
787     //var strings = new List<string>();
788
789     //for (ulong i = 0; i < N; i++)
790     //    strings.Add(RandomHelpers.DefaultFactory.NextUInt64(minNumbers,
791         ↳ maxNumbers).ToString());
792
793     var strings = new List<string>();
794
795     for (ulong i = 0; i < N; i++)
796     {
797         strings.Add(RandomHelpers.Default.NextUInt64().ToString());
798     }
799
800     strings = strings.Distinct().ToList();
801
802     var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
803     var totalCharacters = arrays.Select(x => x.Length).Sum();
804
805     using (var scope1 = new TempLinksTestScope(useSequences: true, sequencesOptions: new
806         ↳ SequencesOptions<ulong> { UseCompression = true,
807         ↳ EnforceSingleSequenceVersionOnWriteBasedOnExisting = true }))
808     using (var scope2 = new TempLinksTestScope(useSequences: true))
809     {
810         scope1.Links.UseUnicode();
811         scope2.Links.UseUnicode();
812
813         var compressor1 = scope1.Sequences;
814         var compressor2 = scope2.Sequences;
815
816         var compressed1 = new ulong[arrays.Length];
817         var compressed2 = new ulong[arrays.Length];
818
819         var sw1 = Stopwatch.StartNew();
820
821         var START = 0;
822         var END = arrays.Length;
823
824         for (int i = START; i < END; i++)
825         {
826             compressed1[i] = compressor1.Create(arrays[i].ShiftRight());
827         }
828     }
829 }

```

```

820     var elapsed1 = sw1.Elapsed;
821
822     var balancedVariantConverter = new BalancedVariantConverter<ulong>(scope2.Links);
823
824     var sw2 = Stopwatch.StartNew();
825
826     for (int i = START; i < END; i++)
827     {
828         compressed2[i] = balancedVariantConverter.Convert(arrays[i]);
829     }
830
831     var elapsed2 = sw2.Elapsed;
832
833     Debug.WriteLine($"Compressor: {elapsed1}, Balanced sequence creator:
834         ↳ {elapsed2}");
835
836     Assert.True(elapsed1 > elapsed2);
837
838     // Checks
839     for (int i = START; i < END; i++)
840     {
841         var sequence1 = compressed1[i];
842         var sequence2 = compressed2[i];
843
844         if (sequence1 != _constants.Null && sequence2 != _constants.Null)
845         {
846             var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
847                 ↳ scope1.Links);
848
849             var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
850                 ↳ scope2.Links);
851
852             Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
853         }
854     }
855
856     Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
857     Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
858
859     Debug.WriteLine($"{{(double)(scope1.Links.Count() - UnicodeMap.MapSize) /
860         ↳ totalCharacters}} | {{(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
861         ↳ totalCharacters}}");
862
863     // Can be worse than balanced variant
864     //Assert.True(scope1.Links.Count() <= scope2.Links.Count());
865
866     //compressor1.ValidateFrequencies();
867 }
868
869 [Fact]
870 public static void AllTreeBreakDownAtSequencesCreationBugTest()
871 {
872     // Made out of AllPossibleConnectionsTest test.
873
874     //const long sequenceLength = 5; //100% bug
875     const long sequenceLength = 4; //100% bug
876     //const long sequenceLength = 3; //100% _no_bug (ok)
877
878     using (var scope = new TempLinksTestScope(useSequences: true))
879     {
880         var links = scope.Links;
881         var sequences = scope.Sequences;
882
883         var sequence = new ulong[sequenceLength];
884         for (var i = 0; i < sequenceLength; i++)
885         {
886             sequence[i] = links.Create();
887         }
888
889         var createResults = sequences.CreateAllVariants2(sequence);
890
891         Global.Trash = createResults;
892
893         for (var i = 0; i < sequenceLength; i++)
894         {
895             links.Delete(sequence[i]);
896         }
897     }
898 }

```

```

894 }
895
896 [Fact]
897 public static void AllPossibleConnectionsTest()
898 {
899     const long sequenceLength = 5;
900
901     using (var scope = new TempLinksTestScope(useSequences: true))
902     {
903         var links = scope.Links;
904         var sequences = scope.Sequences;
905
906         var sequence = new ulong[sequenceLength];
907         for (var i = 0; i < sequenceLength; i++)
908         {
909             sequence[i] = links.Create();
910         }
911
912         var createResults = sequences.CreateAllVariants2(sequence);
913         var reverseResults = sequences.CreateAllVariants2(sequence.Reverse().ToArray());
914
915         for (var i = 0; i < 1; i++)
916         {
917             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
955 [Fact(Skip = "Correct implementation is pending")]
956 public static void CalculateAllUsagesTest()
957 {
958     const long sequenceLength = 3;
959
960     using (var scope = new TempLinksTestScope(useSequences: true))
961     {
962         var links = scope.Links;
963         var sequences = scope.Sequences;
964
965         var sequence = new ulong[sequenceLength];
966         for (var i = 0; i < sequenceLength; i++)
967         {
968             sequence[i] = links.Create();
969         }
970
971         var createResults = sequences.CreateAllVariants2(sequence);
972

```

```

973         //var reverseResults =
974         ↪ sequences.CreateAllVariants2(sequence.Reverse().ToArray());
975
976     for (var i = 0; i < 1; i++)
977     {
978         var linksTotalUsages1 = new ulong[links.Count() + 1];
979
980         sequences.CalculateAllUsages(linksTotalUsages1);
981
982         var linksTotalUsages2 = new ulong[links.Count() + 1];
983
984         sequences.CalculateAllUsages2(linksTotalUsages2);
985
986         var intersection1 = linksTotalUsages1.Intersect(linksTotalUsages2).ToList();
987         Assert.True(intersection1.Count == linksTotalUsages2.Length);
988     }
989
990     for (var i = 0; i < sequenceLength; i++)
991     {
992         links.Delete(sequence[i]);
993     }
994 }
995 }
996 }

```

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

```



```

48     private static void UsingWithExternalReferences<TLink>(Action<ILinks<TLink>> action)
49     {
50         var constants = new LinksConstants<TLink>(enableExternalReferencesSupport: true);
51         using (var dataMemory = new HeapResizableDirectMemory())
52         using (var indexMemory = new HeapResizableDirectMemory())
53         using (var memory = new SplitMemoryLinks<TLink>(dataMemory, indexMemory,
54             ↪ SplitMemoryLinks<TLink>.DefaultLinksSizeStep, constants))
55         {
56             action(memory);
57         }
58     }
59 }

```

1.180 ./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(500));
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     }

```

1.181 ./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(500));
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 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 }

```

1.182 ./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 using Platform.Data.Doublets.Memory.Split.Specific;
7 using Platform.Memory;
8
9 namespace Platform.Data.Doublets.Tests
10 {
11     public class TempLinksTestScope : DisposableBase
12     {
13         public ILinks<ulong> MemoryAdapter { get; }
14         public SynchronizedLinks<ulong> Links { get; }
15         public Sequences.Sequences Sequences { get; }
16         public string TempFilename { get; }
17         public string TempTransactionLogFilename { get; }
18         private readonly bool _deleteFiles;
19
20         public TempLinksTestScope(bool deleteFiles = true, bool useSequences = false, bool
21     ↪ useLog = false) : this(new SequencesOptions<ulong>(), deleteFiles, useSequences,
22     ↪ useLog) { }
23
24         public TempLinksTestScope(SequencesOptions<ulong> sequencesOptions, bool deleteFiles =
25     ↪ true, bool useSequences = false, bool useLog = false)
26         {
27             _deleteFiles = deleteFiles;
28             TempFilename = Path.GetTempFileName();
29             TempTransactionLogFilename = Path.GetTempFileName();
30             //var coreMemoryAdapter = new UInt64UnitedMemoryLinks(TempFilename);
31             var coreMemoryAdapter = new UInt64SplitMemoryLinks(new
32     ↪ FileMappedResizableDirectMemory(TempFilename), new
33     ↪ FileMappedResizableDirectMemory(Path.ChangeExtension(TempFilename, "indexes")),
34     ↪ UInt64SplitMemoryLinks.DefaultLinksSizeStep, new LinksConstants<ulong>(),
35     ↪ Memory.IndexTreeType.Default, useLinkedList: true);

```

```

29     MemoryAdapter = useLog ? (ILinks<ulong>)new
        ↳ UInt64LinksTransactionsLayer(coreMemoryAdapter, TempTransactionLogFilename) :
        ↳ coreMemoryAdapter;
30     Links = new SynchronizedLinks<ulong>(new UInt64Links(MemoryAdapter));
31     if (useSequences)
32     {
33         Sequences = new Sequences.Sequences(Links, sequencesOptions);
34     }
35 }
36
37 protected override void Dispose(bool manual, bool wasDisposed)
38 {
39     if (!wasDisposed)
40     {
41         Links.Unsync.DisposeIfPossible();
42         if (_deleteFiles)
43         {
44             DeleteFiles();
45         }
46     }
47 }
48
49 public void DeleteFiles()
50 {
51     File.Delete(TempFilename);
52     File.Delete(TempTransactionLogFilename);
53 }
54 }
55 }

```

1.183 ./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));
176                 → //-V3086
177                 var resultLink = links.GetOrCreate(source, target);
178                 if (comparer.Compare(resultLink,
179                     → uint64ToAddressConverter.Convert(linksCount)) > 0)
180                 {
181                     created++;
182                 }
183             }
184             else
185             {
186                 links.Create();
187                 created++;
188             }
189         }
190         Assert.True(created == addressToUInt64Converter.Convert(links.Count()));
191         for (var i = 0; i < N; i++)
192         {
193             TLink link = uint64ToAddressConverter.Convert((ulong)i + 1UL);
194             if (links.Exists(link))
195             {
196                 links.Delete(link);
197                 deleted++;
198             }
199         }
200         Assert.True(addressToUInt64Converter.Convert(links.Count()) == 0L);
201     }
202 }

```

1.184 ./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]
35         public static void MultipleCreateAndDeleteTest()
36         {
37             using (var scope = new Scope<Types<HeapResizableDirectMemory,
38                 ↪ UInt64UnitedMemoryLinks>>())
39             {
40                 new UInt64Links(scope.Use<ILinks<ulong>>()).TestMultipleRandomCreationsAndDeletions(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>(scope.TempTransactionLogFilename);
68             }
69
70         [Fact]
71         public static void BasicTransactionLogTest()
72         {
73             using (var scope = new TempLinksTestScope(useLog: true))
74             {
75                 var links = scope.Links;
76                 var l1 = links.Create();

```

```

77         var l2 = links.Create();
78
79         Global.Trash = links.Update(l2, l2, l1, l2);
80
81         links.Delete(l1);
82
83         links.Unsync.DisposeIfPossible(); // Close links to access log
84
85         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(scope ↵
            ↵ e.TempTransactionLogFilename);
86     }
87 }
88
89 [Fact]
90 public static void TransactionAutoRevertedTest()
91 {
92     // Auto Reverted (Because no commit at transaction)
93     using (var scope = new TempLinksTestScope(useLog: true))
94     {
95         var links = scope.Links;
96         var transactionsLayer = (UInt64LinksTransactionsLayer)scope.MemoryAdapter;
97         using (var transaction = transactionsLayer.BeginTransaction())
98         {
99             var l1 = links.Create();
100             var l2 = links.Create();
101
102             links.Update(l2, l2, l1, l2);
103         }
104
105         Assert.Equal(0UL, links.Count());
106
107         links.Unsync.DisposeIfPossible();
108
109         var transitions = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(s ↵
            ↵ cope.TempTransactionLogFilename);
110         Assert.Single(transitions);
111     }
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, ↵
            ↵ useLog: true))
124         {
125             var links = scope.Links;
126             var transactionsLayer = (UInt64LinksTransactionsLayer)((LinksDisposableDecor ↵
            ↵ atorBase<ulong>)links.Unsync).Links;
127             using (var transaction = transactionsLayer.BeginTransaction())
128             {
129                 var l1 = links.CreateAndUpdate(itself, itself);
130                 var l2 = links.CreateAndUpdate(itself, itself);
131
132                 l2 = links.Update(l2, l2, l1, l2);
133
134                 links.CreateAndUpdate(l2, itself);
135                 links.CreateAndUpdate(l2, itself);
136
137                 //Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transi ↵
            ↵ tion>(scope.TempTransactionLogFilename);
138
139                 l2 = links.Update(l2, l1);
140
141                 links.Delete(l2);
142
143                 ExceptionThrower();
144
145                 transaction.Commit();
146             }
147
148             Global.Trash = links.Count();
149         }
150     }

```

```

151     catch
152     {
153         Assert.False(lastScope == null);
154
155         var transitions = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(l
            ↳ astScope.TempTransactionLogFilename);
156
157         Assert.True(transitions.Length == 1 && transitions[0].Before.IsNull() &&
            ↳ transitions[0].After.IsNull());
158
159         lastScope.DeleteFiles();
160     }
161 }
162
163 [Fact]
164 public static void TransactionUserCodeErrorSomeDataSavedTest()
165 {
166     // User Code Error (Autoreverted), some data saved
167     var itself = _constants.Itself;
168
169     TempLinksTestScope lastScope = null;
170     try
171     {
172         ulong l1;
173         ulong l2;
174
175         using (var scope = new TempLinksTestScope(useLog: true))
176         {
177             var links = scope.Links;
178             l1 = links.CreateAndUpdate(itself, itself);
179             l2 = links.CreateAndUpdate(itself, itself);
180
181             l2 = links.Update(l2, l2, l1, l2);
182
183             links.CreateAndUpdate(l2, itself);
184             links.CreateAndUpdate(l2, itself);
185
186             links.Unsync.DisposeIfPossible();
187
188             Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(
                ↳ scope.TempTransactionLogFilename);
189         }
190
191         using (var scope = lastScope = new TempLinksTestScope(deleteFiles: false,
            ↳ useLog: true))
192         {
193             var links = scope.Links;
194             var transactionsLayer = (UInt64LinksTransactionsLayer)links.Unsync;
195             using (var transaction = transactionsLayer.BeginTransaction())
196             {
197                 l2 = links.Update(l2, l1);
198
199                 links.Delete(l2);
200
201                 ExceptionThrower();
202
203                 transaction.Commit();
204             }
205
206             Global.Trash = links.Count();
207         }
208     }
209     catch
210     {
211         Assert.False(lastScope == null);
212
213         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(last
            ↳ Scope.TempTransactionLogFilename);
214
215         lastScope.DeleteFiles();
216     }
217 }
218
219 [Fact]
220 public static void TransactionCommit()
221 {
222     var itself = _constants.Itself;
223
224     var tempDatabaseFilename = Path.GetTempFileName();
225     var tempTransactionLogFilename = Path.GetTempFileName();

```



```

226
227 // Commit
228 using (var memoryAdapter = new UInt64LinksTransactionsLayer(new
    ↳ UInt64UnitedMemoryLinks(tempDatabaseFilename), tempTransactionLogFilename))
229 using (var links = new UInt64Links(memoryAdapter))
230 {
231     using (var transaction = memoryAdapter.BeginTransaction())
232     {
233         var l1 = links.CreateAndUpdate(itself, itself);
234         var l2 = links.CreateAndUpdate(itself, itself);
235
236         Global.Trash = links.Update(l2, l2, l1, l2);
237
238         links.Delete(l1);
239
240         transaction.Commit();
241     }
242
243     Global.Trash = links.Count();
244 }
245
246 Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran_
    ↳ sactionLogFilename);
247
248
249 [Fact]
250 public static void TransactionDamage()
251 {
252     var itself = _constants.Itself;
253
254     var tempDatabaseFilename = Path.GetTempFileName();
255     var tempTransactionLogFilename = Path.GetTempFileName();
256
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
330             Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(temp
    ↪      TransactionLogFilename);
331
332             using (var memory = new UInt64UnitedMemoryLinks(tempDatabaseFilename))
333             using (var memoryAdapter = new UInt64LinksTransactionsLayer(memory,
    ↪      tempTransactionLogFilename))
334             using (var links = new UInt64Links(memoryAdapter))
335             {
336                 using (var transaction = memoryAdapter.BeginTransaction())
337                 {
338                     l2 = links.Update(l2, l1);
339
340                     links.Delete(l2);
341
342                     ExceptionThrower();
343
344                     transaction.Commit();
345                 }
346
347                 Global.Trash = links.Count();
348             }
349         }
350         catch
351         {
352             Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(temp
    ↪      TransactionLogFilename);
353         }
354
355         File.Delete(tempDatabaseFilename);
356         File.Delete(tempTransactionLogFilename);
357     }
358
359     private static void ExceptionThrower() => throw new InvalidOperationException();
360
361     [Fact]
362     public static void PathsTest()
363     {
364         var source = _constants.SourcePart;
365         var target = _constants.TargetPart;
366
367         using (var scope = new TempLinksTestScope())
368         {
369             var links = scope.Links;
370             var l1 = links.CreatePoint();

```

```

371         var l2 = links.CreatePoint();
372
373         var r1 = links.GetByKeys(l1, source, target, source);
374         var r2 = links.CheckPathExistance(l2, l2, l2, l2);
375     }
376 }
377
378 [Fact]
379 public static void RecursiveStringFormattingTest()
380 {
381     using (var scope = new TempLinksTestScope(useSequences: true))
382     {
383         var links = scope.Links;
384         var sequences = scope.Sequences; // TODO: Auto use sequences on Sequences getter.
385
386         var a = links.CreatePoint();
387         var b = links.CreatePoint();
388         var c = links.CreatePoint();
389
390         var ab = links.GetOrCreate(a, b);
391         var cb = links.GetOrCreate(c, b);
392         var ac = links.GetOrCreate(a, c);
393
394         a = links.Update(a, c, b);
395         b = links.Update(b, a, c);
396         c = links.Update(c, a, b);
397
398         Debug.WriteLine(links.FormatStructure(ab, link => link.IsFullPoint(), true));
399         Debug.WriteLine(links.FormatStructure(cb, link => link.IsFullPoint(), true));
400         Debug.WriteLine(links.FormatStructure(ac, link => link.IsFullPoint(), true));
401
402         Assert.True(links.FormatStructure(cb, link => link.IsFullPoint(), true) ==
403             ↪ "(5:(4:5 (6:5 4)) 6)");
404         Assert.True(links.FormatStructure(ac, link => link.IsFullPoint(), true) ==
405             ↪ "(6:(5:(4:5 6) 6) 4)");
406         Assert.True(links.FormatStructure(ab, link => link.IsFullPoint(), true) ==
407             ↪ "(4:(5:4 (6:5 4)) 6)");
408
409         // TODO: Think how to build balanced syntax tree while formatting structure (eg.
410         ↪ "(4:(5:4 6) (6:5 4))" instead of "(4:(5:4 (6:5 4)) 6)"
411
412         Assert.True(sequences.SafeFormatSequence(cb, DefaultFormatter, false) ==
413             ↪ "{5}{5}{4}{6}");
414         Assert.True(sequences.SafeFormatSequence(ac, DefaultFormatter, false) ==
415             ↪ "{5}{6}{6}{4}");
416         Assert.True(sequences.SafeFormatSequence(ab, DefaultFormatter, false) ==
417             ↪ "{4}{5}{4}{6}");
418     }
419 }
420
421 private static void DefaultFormatter(StringBuilder sb, ulong link)
422 {
423     sb.Append(link.ToString());
424 }
425
426 #endregion
427
428 #region Performance
429
430 /*
431 public static void RunAllPerformanceTests()
432 {
433     try
434     {
435         links.TestLinksInSteps();
436     }
437     catch (Exception ex)
438     {
439         ex.WriteToConsole();
440     }
441
442     return;
443
444     try
445     {
446         //ThreadPool.SetMaxThreads(2, 2);
447
448         // Запускаем все тесты дважды, чтобы первоначальная инициализация не повлияла на
449         ↪ результат

```

```

442 // Также это дополнительно помогает в отладке
443 // Увеличивает вероятность попадания информации в кэши
444 for (var i = 0; i < 10; i++)
445 {
446     //0 - 10 ГБ
447     //Каждые 100 МБ срез цифр
448
449     //links.TestGetSourceFunction();
450     //links.TestGetSourceFunctionInParallel();
451     //links.TestGetTargetFunction();
452     //links.TestGetTargetFunctionInParallel();
453     links.Create64BillionLinks();
454
455     links.TestRandomSearchFixed();
456     //links.Create64BillionLinksInParallel();
457     links.TestEachFunction();
458     //links.TestForeach();
459     //links.TestParallelForeach();
460 }
461
462 links.TestDeletionOfAllLinks();
463
464 }
465 catch (Exception ex)
466 {
467     ex.WriteToConsole();
468 }
469 */
470
471 /*
472 public static void TestLinksInSteps()
473 {
474     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         ConsoleHelpers.Debug("C S D (no overhead)");
519
520         for (int i = 0; i < loops; i++)
521         {
522             ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i] - stepLoopOverhead,
523 ↪ searchMeasurements[i] - stepLoopOverhead, deletionMeasurements[i] - stepLoopOverhead);
524         }
525
526         ConsoleHelpers.Debug("All tests done. Total links left in database: {0}.",
527 ↪ links.Total);
528     }
529
530     private static void CreatePoints(this Platform.Links.Data.Core.Doublets.Links links, long
531 ↪ amountToCreate)
532     {
533         for (long i = 0; i < amountToCreate; i++)
534             links.Create(0, 0);
535     }
536
537     private static TimeSpan GetBaseRandomLoopOverhead(long loops)
538     {
539         return Measure(() =>
540         {
541             ulong maxValue = RandomHelpers.DefaultFactory.NextUInt64();
542             ulong result = 0;
543             for (long i = 0; i < loops; i++)
544             {
545                 var source = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
546                 var target = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
547
548                 result += maxValue + source + target;
549             }
550             Global.Trash = result;
551         });
552     }
553
554     /*
555     [Fact(Skip = "performance test")]
556     public static void GetSourceTest()
557     {
558         using (var scope = new TempLinksTestScope())
559         {
560             var links = scope.Links;
561             ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations.",
562 ↪ Iterations);
563
564             ulong counter = 0;
565
566             //var firstLink = links.First();
567             // Создаём одну связь, из которой будет производить считывание
568             var firstLink = links.Create();
569
570             var sw = Stopwatch.StartNew();
571
572             // Тестируем саму функцию
573             for (ulong i = 0; i < Iterations; i++)
574             {
575                 counter += links.GetSource(firstLink);
576             }
577
578             var elapsedTime = sw.Elapsed;
579
580             var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
581
582             // Удаляем связь, из которой производилось считывание
583             links.Delete(firstLink);
584
585             ConsoleHelpers.Debug(
586                 "{0} Iterations of GetSource function done in {1} ({2} Iterations per
587 ↪ second), counter result: {3}",
588                 Iterations, elapsedTime, (long)iterationsPerSecond, counter);
589         }
590     }
591
592     [Fact(Skip = "performance test")]
593     public static void GetSourceInParallel()
594     {
595         using (var scope = new TempLinksTestScope())
596     
```

```

592     {
593         var links = scope.Links;
594         ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations in
        ↳ parallel.", Iterations);
595
596         long counter = 0;
597
598         //var firstLink = links.First();
599         var firstLink = links.Create();
600
601         var sw = Stopwatch.StartNew();
602
603         // Тестируем саму функцию
604         Parallel.For(0, Iterations, x =>
605         {
606             Interlocked.Add(ref counter, (long)links.GetSource(firstLink));
607             //Interlocked.Increment(ref counter);
608         });
609
610         var elapsedTime = sw.Elapsed;
611
612         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
613
614         links.Delete(firstLink);
615
616         ConsoleHelpers.Debug(
617             "{0} Iterations of GetSource function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
618             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
619     }
620 }
621
622 [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.",
        ↳ Iterations);
629
630         ulong counter = 0;
631
632         //var firstLink = links.First();
633         var firstLink = links.Create();
634
635         var sw = Stopwatch.StartNew();
636
637         for (ulong i = 0; i < Iterations; i++)
638         {
639             counter += links.GetTarget(firstLink);
640         }
641
642         var elapsedTime = sw.Elapsed;
643
644         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
645
646         links.Delete(firstLink);
647
648         ConsoleHelpers.Debug(
649             "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
650             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
651     }
652 }
653
654 [Fact(Skip = "performance test")]
655 public static void TestGetTargetInParallel()
656 {
657     using (var scope = new TempLinksTestScope())
658     {
659         var links = scope.Links;
660         ConsoleHelpers.Debug("Testing GetTarget function with {0} Iterations in
        ↳ parallel.", Iterations);
661
662         long counter = 0;
663
664         //var firstLink = links.First();
665         var firstLink = links.Create();
666

```

```

667     var sw = Stopwatch.StartNew();
668
669     Parallel.For(0, Iterations, x =>
670     {
671         Interlocked.Add(ref counter, (long)links.GetTarget(firstLink));
672         //Interlocked.Increment(ref counter);
673     });
674
675     var elapsedTime = sw.Elapsed;
676
677     var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
678
679     links.Delete(firstLink);
680
681     ConsoleHelpers.Debug(
682         "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
        Iterations, elapsedTime, (long)iterationsPerSecond, counter);
683     }
684 }
685
686 // TODO: Заполнить базу данных перед тестом
687 /*
688 [Fact]
689 public void TestRandomSearchFixed()
690 {
691     var tempFilename = Path.GetTempFileName();
692
693     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
694 ↳ DefaultLinksSizeStep))
695     {
696         long iterations = 64 * 1024 * 1024 /
697 ↳ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
698
699         ulong counter = 0;
700         var maxLink = links.Total;
701
702         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.", iterations);
703
704         var sw = Stopwatch.StartNew();
705
706         for (var i = iterations; i > 0; i--)
707         {
708             var source =
709 ↳ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
710             var target =
711 ↳ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
712
713             counter += links.Search(source, target);
714         }
715
716         var elapsedTime = sw.Elapsed;
717
718         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
719
720         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
        ↳ Iterations per second), c: {3}", iterations, elapsedTime, (long)iterationsPerSecond,
        ↳ 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.",
        ↳ links.Count());
739
740         var sw = Stopwatch.StartNew();

```

```

739     for (var i = iterations; i > 0; i--)
740     {
741         var linksAddressRange = new
742             ↪ Range<ulong>(_constants.InternalReferencesRange.Minimum, maxLink);
743
744         var source = RandomHelpers.Default.NextUInt64(linksAddressRange);
745         var target = RandomHelpers.Default.NextUInt64(linksAddressRange);
746
747         counter += links.SearchOrDefault(source, target);
748     }
749     var elapsedTime = sw.Elapsed;
750     var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
751     ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
752     ↪ Iterations per second), c: {3}",
753         iterations, elapsedTime, (long)iterationsPerSecond, counter);
754 }
755 }
756 }
757
758 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
759 public static void TestEach()
760 {
761     using (var scope = new TempLinksTestScope())
762     {
763         var links = scope.Links;
764
765         var counter = new Counter<IList<ulong>, ulong>(links.Constants.Continue);
766
767         ConsoleHelpers.Debug("Testing Each function.");
768
769         var sw = Stopwatch.StartNew();
770
771         links.Each(counter.IncrementAndReturnTrue);
772
773         var elapsedTime = sw.Elapsed;
774
775         var linksPerSecond = counter.Count / elapsedTime.TotalSeconds;
776
777         ConsoleHelpers.Debug("{0} Iterations of Each's handler function done in {1} ({2}
778         ↪ links per second)",
779             counter, elapsedTime, (long)linksPerSecond);
780     }
781 }
782
783 /*
784 [Fact]
785 public static void TestForeach()
786 {
787     var tempFilename = Path.GetTempFileName();
788
789     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
790     ↪ DefaultLinksSizeStep))
791     {
792         ulong counter = 0;
793
794         ConsoleHelpers.Debug("Testing foreach through links.");
795
796         var sw = Stopwatch.StartNew();
797
798         //foreach (var link in links)
799         //{
800             counter++;
801         //}
802
803         var elapsedTime = sw.Elapsed;
804
805         var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
806
807         ConsoleHelpers.Debug("{0} Iterations of Foreach's handler block done in {1} ({2}
808     ↪ links per second)", counter, elapsedTime, (long)linksPerSecond);
809     }
810
811     File.Delete(tempFilename);
812 }
813 */
814 [Fact]

```



```

814     public static void TestParallelForeach()
815     {
816         var tempFilename = Path.GetTempFileName();
817
818         using (var links = new Platform.Links.Data.Core.Doublents.Links(tempFilename,
↵ DefaultLinksSizeStep))
819         {
820             long counter = 0;
821
822             ConsoleHelpers.Debug("Testing parallel foreach through links.");
823
824             var sw = Stopwatch.StartNew();
825
826             //Parallel.ForEach((IEnumerable<ulong>)links, x =>
827             //{
828             //    Interlocked.Increment(ref counter);
829             //});
830
831             var elapsedTime = sw.Elapsed;
832
833             var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
834
835             ConsoleHelpers.Debug("{0} Iterations of Parallel Foreach's handler block done in
↵ {1} ({2} links per second)", counter, elapsedTime, (long)linksPerSecond);
836         }
837
838         File.Delete(tempFilename);
839     }
840     */
841
842     [Fact(Skip = "performance test")]
843     public static void Create64BillionLinks()
844     {
845         using (var scope = new TempLinksTestScope())
846         {
847             var links = scope.Links;
848             var linksBeforeTest = links.Count();
849
850             long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
851
852             ConsoleHelpers.Debug("Creating {0} links.", linksToCreate);
853
854             var elapsedTime = Performance.Measure(() =>
855             {
856                 for (long i = 0; i < linksToCreate; i++)
857                 {
858                     links.Create();
859                 }
860             });
861
862             var linksCreated = links.Count() - linksBeforeTest;
863             var linksPerSecond = linksCreated / elapsedTime.TotalSeconds;
864
865             ConsoleHelpers.Debug("Current links count: {0}.", links.Count());
866
867             ConsoleHelpers.Debug("{0} links created in {1} ({2} links per second)",
↵ linksCreated, elapsedTime,
868                 (long)linksPerSecond);
869         }
870     }
871
872     [Fact(Skip = "performance test")]
873     public static void Create64BillionLinksInParallel()
874     {
875         using (var scope = new TempLinksTestScope())
876         {
877             var links = scope.Links;
878             var linksBeforeTest = links.Count();
879
880             var sw = Stopwatch.StartNew();
881
882             long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
883
884             ConsoleHelpers.Debug("Creating {0} links in parallel.", linksToCreate);
885
886             Parallel.For(0, linksToCreate, x => links.Create());
887
888             var elapsedTime = sw.Elapsed;
889
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 }

```

1.185 ./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 }

```

```
38 }
```

1.186 ./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);
33                 var unaryNumberToAddressConverter = new
34                     ↪ UnaryNumberToAddressOrOperationConverter<ulong>(links,
35                     ↪ powerOf2ToUnaryNumberConverter);
36                 TestCharAndUnicodeSymbolConverters(links, meaningRoot,
37                     ↪ addressToUnaryNumberConverter, unaryNumberToAddressConverter);
38             }
39         }
40
41         [Fact]
42         public static void CharAndRawNumberUnicodeSymbolConvertersTest()
43         {
44             using (var scope = new Scope<Types<HeapResizableDirectMemory,
45                 ↪ UnitedMemoryLinks<ulong>>>())
46             {
47                 var links = scope.Use<ILinks<ulong>>>();
48                 var meaningRoot = links.CreatePoint();
49                 var addressToRawNumberConverter = new AddressToRawNumberConverter<ulong>();
50                 var rawNumberToAddressConverter = new RawNumberToAddressConverter<ulong>();
51                 TestCharAndUnicodeSymbolConverters(links, meaningRoot,
52                     ↪ addressToRawNumberConverter, rawNumberToAddressConverter);
53             }
54         }
55
56         private static void TestCharAndUnicodeSymbolConverters(ILinks<ulong> links, ulong
57             ↪ meaningRoot, IConverter<ulong> addressToNumberConverter, IConverter<ulong>
58             ↪ numberToAddressConverter)
59         {
60             var unicodeSymbolMarker = links.CreateAndUpdate(meaningRoot, links.Constants.Itself);
61             var charToUnicodeSymbolConverter = new CharToUnicodeSymbolConverter<ulong>(links,
62                 ↪ addressToNumberConverter, unicodeSymbolMarker);
63             var originalCharacter = 'H';
64             var characterLink = charToUnicodeSymbolConverter.Convert(originalCharacter);
65             var unicodeSymbolCriterionMatcher = new TargetMatcher<ulong>(links,
66                 ↪ unicodeSymbolMarker);
67             var unicodeSymbolToCharConverter = new UnicodeSymbolToCharConverter<ulong>(links,
68                 ↪ numberToAddressConverter, unicodeSymbolCriterionMatcher);
69             var resultingCharacter = unicodeSymbolToCharConverter.Convert(characterLink);
70             Assert.Equal(originalCharacter, resultingCharacter);
71         }
72
73         [Fact]
74         public static void StringAndUnicodeSequenceConvertersTest()
75         {
76             using (var scope = new TempLinksTestScope())
```

```

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

```

1.187 ./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     }

```

1.188 ./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     }

```

38 }
39 }

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