

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

```

```

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

```

1.10 ./csharp/Platform.Data.Doublets/Decorators/LinksUniquenessResolver.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Data.Doublets.Decorators
7 {
8     public class LinksUniquenessResolver<TLink> : LinksDecoratorBase<TLink>
9     {
10         private static readonly EqualityComparer<TLink> _equalityComparer =
11             ↪ EqualityComparer<TLink>.Default;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public LinksUniquenessResolver(ICollection<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public override TLink Update(ICollection<TLink> restrictions, ICollection<TLink> substitution)
18         {
19             var constants = _constants;
20             var links = _links;
21             var newLinkAddress = links.SearchOrDefault(substitution[constants.SourcePart],
22             ↪ substitution[constants.TargetPart]);
23             if (_equalityComparer.Equals(newLinkAddress, default))
24             {
25                 return links.Update(restrictions, substitution);
26             }
27             return ResolveAddressChangeConflict(restrictions[constants.IndexPart],
28             ↪ newLinkAddress);
29         }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected virtual TLink ResolveAddressChangeConflict(TLink oldLinkAddress, TLink
33             ↪ newLinkAddress)
34         {
35             if (!_equalityComparer.Equals(oldLinkAddress, newLinkAddress) &&
36             ↪ _links.Exists(oldLinkAddress))
37             {
38                 _facade.Delete(oldLinkAddress);
39             }
40             return newLinkAddress;
41         }
42     }
43 }

```

1.11 ./csharp/Platform.Data.Doublets/Decorators/LinksUniquenessValidator.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Data.Doublets.Decorators
7 {
8     public class LinksUniquenessValidator<TLink> : LinksDecoratorBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksUniquenessValidator(ICollection<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public override TLink Update(ICollection<TLink> restrictions, ICollection<TLink> substitution)
15         {
16             var links = _links;
17             var constants = _constants;
18             links.EnsureDoesNotExists(substitution[constants.SourcePart],
19             ↪ substitution[constants.TargetPart]);
20             return links.Update(restrictions, substitution);
21         }
22     }
23 }

```

1.12 ./csharp/Platform.Data.Doublets/Decorators/LinksUsagesValidator.cs

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Data.Doublets.Decorators
7 {
8     public class LinksUsagesValidator<TLink> : LinksDecoratorBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksUsagesValidator(ILinks<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public override TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
15         {
16             var links = _links;
17             links.EnsureNoUsages(restrictions[_constants.IndexPart]);
18             return links.Update(restrictions, substitution);
19         }
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public override void Delete(IList<TLink> restrictions)
23         {
24             var link = restrictions[_constants.IndexPart];
25             var links = _links;
26             links.EnsureNoUsages(link);
27             links.Delete(link);
28         }
29     }
30 }
```

1.13 ./csharp/Platform.Data.Doublets/Decorators/NonNullContentsLinkDeletionResolver.cs

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Data.Doublets.Decorators
7 {
8     public class NonNullContentsLinkDeletionResolver<TLink> : LinksDecoratorBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public NonNullContentsLinkDeletionResolver(ILinks<TLink> links) : base(links) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public override void Delete(IList<TLink> restrictions)
15         {
16             var linkIndex = restrictions[_constants.IndexPart];
17             var links = _links;
18             links.EnforceResetValues(linkIndex);
19             links.Delete(linkIndex);
20         }
21     }
22 }
```

1.14 ./csharp/Platform.Data.Doublets/Decorators/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(IList<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     /////        }
94     /////    }
95     /////    else
96     /////    {
97     /////        Func<T, bool> handler;
98     /////        handler = link =>
99     /////        {
100     /////            var matchedLink = Memory.GetLinkValue(link);
101     /////            var newValue = Memory.GetLinkValue(link);
102     /////            newValue[Constants.IndexPart] = Constants.Itself;
103     /////            newValue[Constants.SourcePart] =
    ↳ Equals(substitution[Constants.SourcePart], Constants.Itself) ?
    ↳ matchedLink[Constants.IndexPart] : substitution[Constants.SourcePart];
104     /////            newValue[Constants.TargetPart] =
    ↳ Equals(substitution[Constants.TargetPart], Constants.Itself) ?
    ↳ matchedLink[Constants.IndexPart] : substitution[Constants.TargetPart];
105     /////            var matchDecision = matchedHandler(matchedLink, newValue);
106     /////            if (Equals(matchDecision, Constants.Break))
107     /////            {
108     /////                return false;
109     /////            }
110     /////            if (!Equals(matchDecision, Constants.Skip))
111     /////            {
112     /////                transitions.Add(new Transition(matchedLink, newValue));
113     /////            }
114     /////            return true;
115     /////        };
116     /////        if (!Memory.Each(handler, restriction))
117     /////        {
118     /////            return Constants.Break;
119     /////        }
120     /////    }
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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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999     // }
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     /// |         |         |   link   | |
311     /// |         |         |-----| |
312     /// |         |         |   change  | |
313     /// |-----|-----|
314     ///         changes
315     /// </remarks>
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
10     /// <summary>
11     /// <para>.</para>
12     /// <para>.</para>
13     /// </summary>
14     /// <typeparam>
15     /// <para>.</para>
16     /// <para>.</para>
17     /// </typeparam>
18     public struct Doublet<T> : IEquatable<Doublet<T>>
19     {
20         private static readonly EqualityComparer<T> _equalityComparer =
    ↪ EqualityComparer<T>.Default;
21
22         /// <summary>
23         /// <para>.</para>
24         /// <para>.</para>
25         /// </summary>
26         /// <typeparam name="T">
27         /// <para>.</para>
28         /// <para>.</para>
29         /// </typeparam>
30         public readonly T Source;
31
32         /// <summary>
33         /// <para>.</para>
34         /// <para>.</para>
35         /// </summary>
36         /// <typeparam name="T">
37         /// <para>.</para>
38         /// <para>.</para>
39         /// </typeparam>
40         public readonly T Target;
41
42         /// <summary>
43         /// <para>.</para>
44         /// <para>.</para>
45         /// </summary>
46         /// <typeparam name="T">
47         /// <para>.</para>
48         /// <para>.</para>
49         /// </typeparam>
50         /// <param name="source">
51         /// <para>.</para>
52         /// <para>.</para>

```

```

53     /// </param>
54     /// <param name="target">
55     /// <para>.</para>
56     /// <para>.</para>
57     /// </param>
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     public Doublet(T source, T target)
60     {
61         Source = source;
62         Target = target;
63     }
64
65     /// <summary>
66     /// <para>.</para>
67     /// <para>.</para>
68     /// </summary>
69     /// <returns>
70     /// <para>.</para>
71     /// <para>.</para>
72     /// </returns>
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     public override string ToString() => $"{Source}->{Target}";
75
76     /// <summary>
77     /// <para>.</para>
78     /// <para>.</para>
79     /// </summary>
80     /// <typeparam>
81     /// <para>.</para>
82     /// <para>.</para>
83     /// </typeparam>
84     /// <param name="other">
85     /// <para>.</para>
86     /// <para>.</para>
87     /// </param>
88     /// <returns>
89     /// <para>.</para>
90     /// <para>.</para>
91     /// </returns>
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     public bool Equals(Doublet<T> other) => _equalityComparer.Equals(Source, other.Source)
94     ↪ && _equalityComparer.Equals(Target, other.Target);
95
96     /// <summary>
97     /// <para>.</para>
98     /// <para>.</para>
99     /// </summary>
100    /// <typeparam>
101    /// <para>.</para>
102    /// <para>.</para>
103    /// </typeparam>
104    /// <param name="obj">
105    /// <para>.</para>
106    /// <para>.</para>
107    /// </param>
108    /// <returns>
109    /// <para>.</para>
110    /// <para>.</para>
111    /// </returns>
112    [MethodImpl(MethodImplOptions.AggressiveInlining)]
113    public override bool Equals(object obj) => obj is Doublet<T> doublet ?
114    ↪ base.Equals(doublet) : false;
115
116    /// <summary>
117    /// <para>.</para>
118    /// <para>.</para>
119    /// </summary>
120    /// <returns>
121    /// <para>.</para>
122    /// <para>.</para>
123    /// </returns>
124    [MethodImpl(MethodImplOptions.AggressiveInlining)]
125    public override int GetHashCode() => (Source, Target).GetHashCode();
126
127    /// <summary>
128    /// <para>.</para>
129    /// <para>.</para>
130    /// </summary>

```

```

129     /// <param name="left">
130     /// <para>.</para>
131     /// <para>.</para>
132     /// </param>
133     /// <param name="right">
134     /// <para>.</para>
135     /// <para>.</para>
136     /// </param>
137     /// <returns>
138     /// <para>.</para>
139     /// <para>.</para>
140     /// </returns>
141     [MethodImpl(MethodImplOptions.AggressiveInlining)]
142     public static bool operator ==(Doublet<T> left, Doublet<T> right) => left.Equals(right);
143
144     /// <summury>
145     /// <para>.</para>
146     /// <para>.</para>
147     /// </summury>
148     /// <param name="left">
149     /// <para>.</para>
150     /// <para>.</para>
151     /// </param>
152     /// <param name="right">
153     /// <para>.</para>
154     /// <para>.</para>
155     /// </param>
156     /// <returns>
157     /// <para>.</para>
158     /// <para>.</para>
159     /// </returns>
160     [MethodImpl(MethodImplOptions.AggressiveInlining)]
161     public static bool operator !=(Doublet<T> left, Doublet<T> right) => !(left == right);
162 }
163 }

```

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 = OUL; 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 = OUL; i < amountOfSearches; i++)
48             {
49                 var linksAddressRange = new Range<ulong>(0,
50                     ↳ addressToUInt64Converter.Convert(links.Count()));
51                 var source =
52                     ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
53                 var target =
54                     ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
55                 links.SearchOrDefault(source, target);
56             }
57         }
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         public static void RunRandomDeletions<TLink>(this ILinks<TLink> links, ulong
61             ↳ amountOfDeletions)
62         {
63             var random = RandomHelpers.Default;
64             var addressToUInt64Converter = UncheckedConverter<TLink, ulong>.Default;
65             var uint64ToAddressConverter = UncheckedConverter<ulong, TLink>.Default;
66             var linksCount = addressToUInt64Converter.Convert(links.Count());
67             var min = amountOfDeletions > linksCount ? OUL : linksCount - amountOfDeletions;
68             for (var i = OUL; i < amountOfDeletions; i++)
69             {
70                 linksCount = addressToUInt64Converter.Convert(links.Count());
71                 if (linksCount <= min)
72                 {
73                     break;
74                 }
75                 var linksAddressRange = new Range<ulong>(min, linksCount);
76                 var link =
77                     ↳ uint64ToAddressConverter.Convert(random.NextUInt64(linksAddressRange));
78                 links.Delete(link);
79             }
80         }
81
82         [MethodImpl(MethodImplOptions.AggressiveInlining)]
83         public static void Delete<TLink>(this ILinks<TLink> links, TLink linkToDelete) =>
84             ↳ links.Delete(new LinkAddress<TLink>(linkToDelete));
85     }
86 }

```



```

75  /// <remarks>
76  /// TODO: Возможно есть очень простой способ это сделать.
77  /// (Например просто удалить файл, или изменить его размер таким образом,
78  /// чтобы удалился весь контент)
79  /// Например через _header->AllocatedLinks в ResizableDirectMemoryLinks
80  /// </remarks>
81  [MethodImpl(MethodImplOptions.AggressiveInlining)]
82  public static void DeleteAll<TLink>(this ILinks<TLink> links)
83  {
84      var equalityComparer = EqualityComparer<TLink>.Default;
85      var comparer = Comparer<TLink>.Default;
86      for (var i = links.Count(); comparer.Compare(i, default) > 0; i =
87          ↪ Arithmetic.Decrement(i))
88      {
89          links.Delete(i);
90          if (!equalityComparer.Equals(links.Count(), Arithmetic.Decrement(i)))
91          {
92              i = links.Count();
93          }
94      }
95  }
96  [MethodImpl(MethodImplOptions.AggressiveInlining)]
97  public static TLink First<TLink>(this ILinks<TLink> links)
98  {
99      TLink firstLink = default;
100     var equalityComparer = EqualityComparer<TLink>.Default;
101     if (equalityComparer.Equals(links.Count(), default))
102     {
103         throw new InvalidOperationException("В хранилище нет связей.");
104     }
105     links.Each(links.Constants.Any, links.Constants.Any, link =>
106     {
107         firstLink = link[links.Constants.IndexPart];
108         return links.Constants.Break;
109     });
110     if (equalityComparer.Equals(firstLink, default))
111     {
112         throw new InvalidOperationException("В процессе поиска по хранилищу не было
113             ↪ найдено связей.");
114     }
115     return firstLink;
116 }
117 [MethodImpl(MethodImplOptions.AggressiveInlining)]
118 public static IList<TLink> SingleOrDefault<TLink>(this ILinks<TLink> links, IList<TLink>
119     ↪ query)
120 {
121     IList<TLink> result = null;
122     var count = 0;
123     var constants = links.Constants;
124     var @continue = constants.Continue;
125     var @break = constants.Break;
126     links.Each(linkHandler, query);
127     return result;
128 }
129 TLink linkHandler(IList<TLink> link)
130 {
131     if (count == 0)
132     {
133         result = link;
134         count++;
135         return @continue;
136     }
137     else
138     {
139         result = null;
140         return @break;
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

```

```

150 /// Stack в конкретный путь из Source, Target до связи, но это не всегда так.
151 /// TODO: Возможно нужен метод, который именно выбрасывает исключения (EnsurePathExists)
152 /// </remarks>
153 [MethodImpl(MethodImplOptions.AggressiveInlining)]
154 public static bool CheckPathExistance<TLink>(this ILinks<TLink> links, params TLink[]
    ↪ path)
155 {
156     var current = path[0];
157     //EnsureLinkExists(current, "path");
158     if (!links.Exists(current))
159     {
160         return false;
161     }
162     var equalityComparer = EqualityComparer<TLink>.Default;
163     var constants = links.Constants;
164     for (var i = 1; i < path.Length; i++)
165     {
166         var next = path[i];
167         var values = links.GetLink(current);
168         var source = values[constants.SourcePart];
169         var target = values[constants.TargetPart];
170         if (equalityComparer.Equals(source, target) && equalityComparer.Equals(source,
            ↪ next))
171         {
172             //throw new InvalidOperationException(string.Format("Невозможно выбрать
            ↪ путь, так как и Source и Target совпадают с элементом пути {0}.", next));
173             return false;
174         }
175         if (!equalityComparer.Equals(next, source) && !equalityComparer.Equals(next,
            ↪ target))
176         {
177             //throw new InvalidOperationException(string.Format("Невозможно продолжить
            ↪ путь через элемент пути {0}", next));
178             return false;
179         }
180         current = next;
181     }
182     return true;
183 }
184
185 /// <remarks>
186 /// Может потребовать дополнительного стека для PathElement's при использовании
    ↪ SequenceWalker.
187 /// </remarks>
188 [MethodImpl(MethodImplOptions.AggressiveInlining)]
189 public static TLink GetByKeyes<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;

```

```

}
#endregion

/// <summary>
/// Возвращает индекс указанной связи.
/// </summary>
/// <param name="links">Хранилище связей.</param>
/// <param name="link">Связь представленная списком, состоящим из её адреса и
  ↳ содержимого.</param>
/// <returns>Индекс начальной связи для указанной связи.</returns>
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static TLink GetIndex<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
  ↳ link[links.Constants.IndexPart];

/// <summary>
/// Возвращает индекс начальной (Source) связи для указанной связи.
/// </summary>
/// <param name="links">Хранилище связей.</param>
/// <param name="link">Индекс связи.</param>
/// <returns>Индекс начальной связи для указанной связи.</returns>
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static TLink GetSource<TLink>(this ILinks<TLink> links, TLink link) =>
  ↳ links.GetLink(link)[links.Constants.SourcePart];

/// <summary>
/// Возвращает индекс начальной (Source) связи для указанной связи.
/// </summary>
/// <param name="links">Хранилище связей.</param>
/// <param name="link">Связь представленная списком, состоящим из её адреса и
  ↳ содержимого.</param>
/// <returns>Индекс начальной связи для указанной связи.</returns>
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static TLink GetSource<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
  ↳ link[links.Constants.SourcePart];

/// <summary>
/// Возвращает индекс конечной (Target) связи для указанной связи.
/// </summary>
/// <param name="links">Хранилище связей.</param>
/// <param name="link">Индекс связи.</param>
/// <returns>Индекс конечной связи для указанной связи.</returns>
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static TLink GetTarget<TLink>(this ILinks<TLink> links, TLink link) =>
  ↳ links.GetLink(link)[links.Constants.TargetPart];

/// <summary>
/// Возвращает индекс конечной (Target) связи для указанной связи.
/// </summary>
/// <param name="links">Хранилище связей.</param>
/// <param name="link">Связь представленная списком, состоящим из её адреса и
  ↳ содержимого.</param>
/// <returns>Индекс конечной связи для указанной связи.</returns>
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static TLink GetTarget<TLink>(this ILinks<TLink> links, IList<TLink> link) =>
  ↳ link[links.Constants.TargetPart];

/// <summary>
/// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
  ↳ (handler) для каждой подходящей связи.
/// </summary>
/// <param name="links">Хранилище связей.</param>
/// <param name="handler">Обработчик каждой подходящей связи.</param>
/// <param name="restrictions">Ограничения на содержимое связей. Каждое ограничение
  ↳ может иметь значения: Constants.Null - 0-я связь, обозначающая ссылку на пустоту,
  ↳ Any - отсутствие ограничения, 1..∞ конкретный адрес связи.</param>
/// <returns>True, в случае если проход по связям не был прерван и False в обратном
  ↳ случае.</returns>
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public static bool Each<TLink>(this ILinks<TLink> links, Func<IList<TLink>, TLink>
  ↳ handler, params TLink[] restrictions)
  => EqualityComparer<TLink>.Default.Equals(links.Each(handler, restrictions),
    ↳ links.Constants.Continue);

/// <summary>
/// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
  ↳ (handler) для каждой подходящей связи.

```

```

281 /// </summary>
282 /// <param name="links">Хранилище связей.</param>
283 /// <param name="source">Значение, определяющее соответствующие шаблону связи.
    ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве начала,
    ↳ Constants.Any - любое начало, 1..∞ конкретное начало)</param>
284 /// <param name="target">Значение, определяющее соответствующие шаблону связи.
    ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве конца,
    ↳ Constants.Any - любой конец, 1..∞ конкретный конец)</param>
285 /// <param name="handler">Обработчик каждой подходящей связи.</param>
286 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
    ↳ случае.</returns>
287 [MethodImpl(MethodImplOptions.AggressiveInlining)]
288 public static bool Each<TLink>(this ILinks<TLink> links, TLink source, TLink target,
    ↳ Func<TLink, bool> handler)
289 {
290     var constants = links.Constants;
291     return links.Each(link => handler(link[constants.IndexPart]) ? constants.Continue :
    ↳ constants.Break, constants.Any, source, target);
292 }
293
294 /// <summary>
295 /// Выполняет проход по всем связям, соответствующим шаблону, вызывая обработчик
    ↳ (handler) для каждой подходящей связи.
296 /// </summary>
297 /// <param name="links">Хранилище связей.</param>
298 /// <param name="source">Значение, определяющее соответствующие шаблону связи.
    ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве начала,
    ↳ Constants.Any - любое начало, 1..∞ конкретное начало)</param>
299 /// <param name="target">Значение, определяющее соответствующие шаблону связи.
    ↳ (Constants.Null - 0-я связь, обозначающая ссылку на пустоту в качестве конца,
    ↳ Constants.Any - любой конец, 1..∞ конкретный конец)</param>
300 /// <param name="handler">Обработчик каждой подходящей связи.</param>
301 /// <returns>True, в случае если проход по связям не был прерван и False в обратном
    ↳ случае.</returns>
302 [MethodImpl(MethodImplOptions.AggressiveInlining)]
303 public static bool Each<TLink>(this ILinks<TLink> links, TLink source, TLink target,
    ↳ Func<IList<TLink>, TLink> handler) => links.Each(handler, links.Constants.Any,
    ↳ source, target);
304
305 [MethodImpl(MethodImplOptions.AggressiveInlining)]
306 public static IList<IList<TLink>> All<TLink>(this ILinks<TLink> links, params TLink[]
    ↳ 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
341   ↳ в хранилище связей.
342 /// </summary>
343 /// <param name="links">Хранилище связей.</param>
344 /// <param name="source">Начало связи.</param>
345 /// <param name="target">Конец связи.</param>
346 /// <returns>Значение, определяющее существует ли связь.</returns>
347 [MethodImpl(MethodImplOptions.AggressiveInlining)]
348 public static bool Exists<TLink>(this ILinks<TLink> links, TLink source, TLink target)
349   ↳ => Comparer<TLink>.Default.Compare(links.Count(links.Constants.Any, source, target),
350   ↳ default) > 0;
351
352 #region Ensure
353 // TODO: May be move to EnsureExtensions or make it both there and here
354
355 [MethodImpl(MethodImplOptions.AggressiveInlining)]
356 public static void EnsureLinkExists<TLink>(this ILinks<TLink> links, IList<TLink>
357   ↳ restrictions)
358 {
359     for (var i = 0; i < restrictions.Count; i++)
360     {
361         if (!links.Exists(restrictions[i]))
362         {
363             throw new ArgumentLinkDoesNotExistsException<TLink>(restrictions[i],
364               ↳ $"sequence[{i}]");
365         }
366     }
367 }
368
369 [MethodImpl(MethodImplOptions.AggressiveInlining)]
370 public static void EnsureInnerReferenceExists<TLink>(this ILinks<TLink> links, TLink
371   ↳ reference, string argumentName)
372 {
373     if (links.Constants.IsInternalReference(reference) && !links.Exists(reference))
374     {
375         throw new ArgumentLinkDoesNotExistsException<TLink>(reference, argumentName);
376     }
377 }
378
379 [MethodImpl(MethodImplOptions.AggressiveInlining)]
380 public static void EnsureInnerReferenceExists<TLink>(this ILinks<TLink> links,
381   ↳ IList<TLink> restrictions, string argumentName)
382 {
383     for (int i = 0; i < restrictions.Count; i++)
384     {
385         links.EnsureInnerReferenceExists(restrictions[i], argumentName);
386     }
387 }
388
389 [MethodImpl(MethodImplOptions.AggressiveInlining)]
390 public static void EnsureLinkIsAnyOrExists<TLink>(this ILinks<TLink> links, IList<TLink>
391   ↳ restrictions)
392 {
393     var equalityComparer = EqualityComparer<TLink>.Default;
394     var any = links.Constants.Any;
395     for (var i = 0; i < restrictions.Count; i++)
396     {
397         if (!equalityComparer.Equals(restrictions[i], any) &&
398           ↳ !links.Exists(restrictions[i]))
399         {
400             throw new ArgumentLinkDoesNotExistsException<TLink>(restrictions[i],
401               ↳ $"sequence[{i}]");
402         }
403     }
404 }
405
406 [MethodImpl(MethodImplOptions.AggressiveInlining)]
407 public static void EnsureLinkIsAnyOrExists<TLink>(this ILinks<TLink> links, TLink link,
408   ↳ string argumentName)
409 {
410     var equalityComparer = EqualityComparer<TLink>.Default;
411     if (!equalityComparer.Equals(link, links.Constants.Any) && !links.Exists(link))
412     {
413         throw new ArgumentLinkDoesNotExistsException<TLink>(link, argumentName);
414     }
415 }

```

```

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,
481         ↪ constants.Any));
482     var equalityComparer = EqualityComparer<TLink>.Default;
483     if (equalityComparer.Equals(values[constants.SourcePart], link))
484     {
485         usagesAsSource = Arithmetic<TLink>.Decrement(usagesAsSource);
486     }
487     TLink usagesAsTarget = links.Count(new Link<TLink>(constants.Any, constants.Any,
488         ↪ link));
489     if (equalityComparer.Equals(values[constants.TargetPart], link))
490     {
491         usagesAsTarget = Arithmetic<TLink>.Decrement(usagesAsTarget);
492     }
493     return Arithmetic<TLink>.Add(usagesAsSource, usagesAsTarget);
494 }
495
496 /// <param name="links">Хранилище связей.</param>
497 [MethodImpl(MethodImplOptions.AggressiveInlining)]
498 public static bool HasUsages<TLink>(this ILinks<TLink> links, TLink link) =>
499     ↪ Comparer<TLink>.Default.Compare(links.CountUsages(link), default) > 0;
500
501 /// <param name="links">Хранилище связей.</param>
502 [MethodImpl(MethodImplOptions.AggressiveInlining)]
503 public static bool Equals<TLink>(this ILinks<TLink> links, TLink link, TLink source,
504     ↪ TLink target)
505 {
506     var constants = links.Constants;
507     var values = links.GetLink(link);
508     var equalityComparer = EqualityComparer<TLink>.Default;
509     return equalityComparer.Equals(values[constants.SourcePart], source) &&
510         ↪ equalityComparer.Equals(values[constants.TargetPart], target);
511 }
512
513 /// <summary>
514 /// Выполняет поиск связи с указанными Source (началом) и Target (концом).
515 /// </summary>
516 /// <param name="links">Хранилище связей.</param>
517 /// <param name="source">Индекс связи, которая является началом для искомой
518     ↪ связи.</param>
519 /// <param name="target">Индекс связи, которая является концом для искомой связи.</param>
520 /// <returns>Индекс искомой связи с указанными Source (началом) и Target
521     ↪ (концом).</returns>
522 [MethodImpl(MethodImplOptions.AggressiveInlining)]
523 public static TLink SearchOrDefault<TLink>(this ILinks<TLink> links, TLink source, TLink
524     ↪ target)
525 {
526     var constants = links.Constants;
527     var setter = new Setter<TLink, TLink>(constants.Continue, constants.Break, default);
528     links.Each(setter.SetFirstAndReturnFalse, constants.Any, source, target);
529     return setter.Result;
530 }
531
532 /// <param name="links">Хранилище связей.</param>
533 [MethodImpl(MethodImplOptions.AggressiveInlining)]
534 public static TLink Create<TLink>(this ILinks<TLink> links) => links.Create(null);
535
536 /// <param name="links">Хранилище связей.</param>
537 [MethodImpl(MethodImplOptions.AggressiveInlining)]
538 public static TLink CreatePoint<TLink>(this ILinks<TLink> links)
539 {
540     var link = links.Create();
541     return links.Update(link, link, link);
542 }
543
544 /// <param name="links">Хранилище связей.</param>
545 [MethodImpl(MethodImplOptions.AggressiveInlining)]
546 public static TLink CreateAndUpdate<TLink>(this ILinks<TLink> links, TLink source, TLink
547     ↪ target) => links.Update(links.Create(), source, target);
548
549 /// <summary>
550 /// 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
    → выполняется обновление.</param>
547     /// <param name="newTarget">Индекс связи, которая является концом связи, на которую
    → выполняется обновление.</param>
548     /// <returns>Индекс обновлённой связи.</returns>
549     [MethodImpl(MethodImplOptions.AggressiveInlining)]
550     public static TLink Update<TLink>(this ILinks<TLink> links, TLink link, TLink newSource,
    → TLink newTarget) => links.Update(new LinkAddress<TLink>(link), new Link<TLink>(link,
    → newSource, newTarget));
551
552     /// <summary>
553     /// Обновляет связь с указанными началом (Source) и концом (Target)
554     /// на связь с указанными началом (NewSource) и концом (NewTarget).
555     /// </summary>
556     /// <param name="links">Хранилище связей.</param>
557     /// <param name="restrictions">Ограничения на содержимое связей. Каждое ограничение
    → может иметь значения: Constants.Null - 0-я связь, обозначающая ссылку на пустоту,
    → Itself - требование установить ссылку на себя, 1.. $\infty$  конкретный адрес другой
    → связи.</param>
558     /// <returns>Индекс обновлённой связи.</returns>
559     [MethodImpl(MethodImplOptions.AggressiveInlining)]
560     public static TLink Update<TLink>(this ILinks<TLink> links, params TLink[] restrictions)
561     {
562         if (restrictions.Length == 2)
563         {
564             return links.MergeAndDelete(restrictions[0], restrictions[1]);
565         }
566         if (restrictions.Length == 4)
567         {
568             return links.UpdateOrCreateOrGet(restrictions[0], restrictions[1],
    → restrictions[2], restrictions[3]);
569         }
570         else
571         {
572             return links.Update(new LinkAddress<TLink>(restrictions[0]), restrictions);
573         }
574     }
575
576     [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
    → values - source and target are reset to null) or it might enter into infinite
    → recursion.</remarks>
667 [MethodImpl(MethodImplOptions.AggressiveInlining)]
668 public static void DeleteAllUsages<TLink>(this ILinks<TLink> links, TLink linkIndex)
669 {
670     var anyConstant = links.Constants.Any;
671     var usagesAsSourceQuery = new Link<TLink>(anyConstant, linkIndex, anyConstant);
672     links.DeleteByQuery(usagesAsSourceQuery);
673     var usagesAsTargetQuery = new Link<TLink>(anyConstant, linkIndex, anyConstant);
674     links.DeleteByQuery(usagesAsTargetQuery);
675 }

```

```

676 [MethodImpl(MethodImplOptions.AggressiveInlining)]
677 public static void DeleteByQuery<TLink>(this ILinks<TLink> links, Link<TLink> query)
678 {
679     var count = CheckedConverter<TLink, long>.Default.Convert(links.Count(query));
680     if (count > 0)
681     {
682         var queryResult = new TLink[count];
683         var queryResultFiller = new ArrayFiller<TLink, TLink>(queryResult,
684             ↪ links.Constants.Continue);
685         links.Each(queryResultFiller.AddFirstAndReturnConstant, query);
686         for (var i = count - 1; i >= 0; i--)
687         {
688             links.Delete(queryResult[i]);
689         }
690     }
691 }
692
693 // TODO: Move to Platform.Data
694 [MethodImpl(MethodImplOptions.AggressiveInlining)]
695 public static bool AreValuesReset<TLink>(this ILinks<TLink> links, TLink linkIndex)
696 {
697     var nullConstant = links.Constants.Null;
698     var equalityComparer = EqualityComparer<TLink>.Default;
699     var link = links.GetLink(linkIndex);
700     for (int i = 1; i < link.Count; i++)
701     {
702         if (!equalityComparer.Equals(link[i], nullConstant))
703         {
704             return false;
705         }
706     }
707     return true;
708 }
709
710 // TODO: Create a universal version of this method in Platform.Data (with using of for
711 ↪ loop)
712 [MethodImpl(MethodImplOptions.AggressiveInlining)]
713 public static void ResetValues<TLink>(this ILinks<TLink> links, TLink linkIndex)
714 {
715     var nullConstant = links.Constants.Null;
716     var updateRequest = new Link<TLink>(linkIndex, nullConstant, nullConstant);
717     links.Update(updateRequest);
718 }
719
720 // TODO: Create a universal version of this method in Platform.Data (with using of for
721 ↪ loop)
722 [MethodImpl(MethodImplOptions.AggressiveInlining)]
723 public static void EnforceResetValues<TLink>(this ILinks<TLink> links, TLink linkIndex)
724 {
725     if (!links.AreValuesReset(linkIndex))
726     {
727         links.ResetValues(linkIndex);
728     }
729 }
730
731 /// <summary>
732 /// Merging two usages graphs, all children of old link moved to be children of new link
733 ↪ or deleted.
734 /// </summary>
735 [MethodImpl(MethodImplOptions.AggressiveInlining)]
736 public static TLink MergeUsages<TLink>(this ILinks<TLink> links, TLink oldLinkIndex,
737     ↪ TLink newLinkIndex)
738 {
739     var addressToInt64Converter = CheckedConverter<TLink, long>.Default;
740     var equalityComparer = EqualityComparer<TLink>.Default;
741     if (!equalityComparer.Equals(oldLinkIndex, newLinkIndex))
742     {
743         var constants = links.Constants;
744         var usagesAsSourceQuery = new Link<TLink>(constants.Any, oldLinkIndex,
745             ↪ constants.Any);
746         var usagesAsSourceCount =
747             ↪ addressToInt64Converter.Convert(links.Count(usagesAsSourceQuery));
748         var usagesAsTargetQuery = new Link<TLink>(constants.Any, constants.Any,
749             ↪ oldLinkIndex);
750         var usagesAsTargetCount =
751             ↪ addressToInt64Converter.Convert(links.Count(usagesAsTargetQuery));

```

```

744     var isStandalonePoint = Point<TLink>.IsFullPoint(links.GetLink(oldLinkIndex)) &&
745         ↳ usagesAsSourceCount == 1 && usagesAsTargetCount == 1;
746     if (!isStandalonePoint)
747     {
748         var totalUsages = usagesAsSourceCount + usagesAsTargetCount;
749         if (totalUsages > 0)
750         {
751             var usages = ArrayPool.Allocate<TLink>(totalUsages);
752             var usagesFiller = new ArrayFiller<TLink, TLink>(usages,
753                 ↳ links.Constants.Continue);
754             var i = 0L;
755             if (usagesAsSourceCount > 0)
756             {
757                 links.Each(usagesFiller.AddFirstAndReturnConstant,
758                     ↳ usagesAsSourceQuery);
759                 for (; i < usagesAsSourceCount; i++)
760                 {
761                     var usage = usages[i];
762                     if (!equalityComparer.Equals(usage, oldLinkIndex))
763                     {
764                         links.Update(usage, newLinkIndex, links.GetTarget(usage));
765                     }
766                 }
767             }
768             if (usagesAsTargetCount > 0)
769             {
770                 links.Each(usagesFiller.AddFirstAndReturnConstant,
771                     ↳ usagesAsTargetQuery);
772                 for (; i < usages.Length; i++)
773                 {
774                     var usage = usages[i];
775                     if (!equalityComparer.Equals(usage, oldLinkIndex))
776                     {
777                         links.Update(usage, links.GetSource(usage), newLinkIndex);
778                     }
779                 }
780             }
781             ArrayPool.Free(usages);
782         }
783     }
784     return newLinkIndex;
785 }
786
787 /// <summary>
788 /// Replace one link with another (replaced link is deleted, children are updated or
789   ↳ deleted).
790 /// </summary>
791 [MethodImpl(MethodImplOptions.AggressiveInlining)]
792 public static TLink MergeAndDelete<TLink>(this ILinks<TLink> links, TLink oldLinkIndex,
793     ↳ TLink newLinkIndex)
794 {
795     var equalityComparer = EqualityComparer<TLink>.Default;
796     if (!equalityComparer.Equals(oldLinkIndex, newLinkIndex))
797     {
798         links.MergeUsages(oldLinkIndex, newLinkIndex);
799         links.Delete(oldLinkIndex);
800     }
801     return newLinkIndex;
802 }
803
804 [MethodImpl(MethodImplOptions.AggressiveInlining)]
805 public static ILinks<TLink>
806     ↳ DecorateWithAutomaticUniquenessAndUsagesResolution<TLink>(this ILinks<TLink> links)
807 {
808     links = new LinksCascadeUsagesResolver<TLink>(links);
809     links = new NonNullContentsLinkDeletionResolver<TLink>(links);
810     links = new LinksCascadeUniquenessAndUsagesResolver<TLink>(links);
811     return links;
812 }
813
814 [MethodImpl(MethodImplOptions.AggressiveInlining)]
815 public static string Format<TLink>(this ILinks<TLink> links, IList<TLink> link)
816 {
817     var constants = links.Constants;
818     return $"{link[constants.IndexPart]}: {link[constants.SourcePart]}
819         ↳ {link[constants.TargetPart]}";
820 }

```

```

814     [MethodImpl(MethodImplOptions.AggressiveInlining)]
815     public static string Format<TLink>(this ILinks<TLink> links, TLink link) =>
816         ↪ 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>,
6          ↪ LinksConstants<TLink>>, ILinks<TLink>
7      {
8      }
9  }

```

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 =
12             ↪ EqualityComparer<TLink>.Default;
13
14         private readonly TLink _frequencyMarker;
15         private readonly TLink _unaryOne;
16         private readonly IIncrementer<TLink> _unaryNumberIncrementer;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public FrequencyIncrementer(ILinks<TLink> links, TLink frequencyMarker, TLink unaryOne,
20             ↪ IIncrementer<TLink> unaryNumberIncrementer)
21             : base(links)
22         {
23             _frequencyMarker = frequencyMarker;
24             _unaryOne = unaryOne;
25             _unaryNumberIncrementer = unaryNumberIncrementer;
26         }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public TLink Increment(TLink frequency)
30         {
31             var links = _links;
32             if (_equalityComparer.Equals(frequency, default))
33             {
34                 return links.GetOrCreate(_unaryOne, _frequencyMarker);
35             }
36             var incrementedSource =
37                 ↪ _unaryNumberIncrementer.Increment(links.GetSource(frequency));
38             return links.GetOrCreate(incrementedSource, _frequencyMarker);
39         }
40     }
41 }

```

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 }

```

```

17     [MethodImpl(MethodImplOptions.AggressiveInlining)]
18     public TLink Increment(TLink unaryNumber)
19     {
20         var links = _links;
21         if (_equalityComparer.Equals(unaryNumber, _unaryOne))
22         {
23             return links.GetOrCreate(_unaryOne, _unaryOne);
24         }
25         var source = links.GetSource(unaryNumber);
26         var target = links.GetTarget(unaryNumber);
27         if (_equalityComparer.Equals(source, target))
28         {
29             return links.GetOrCreate(unaryNumber, _unaryOne);
30         }
31         else
32         {
33             return links.GetOrCreate(source, Increment(target));
34         }
35     }
36 }
37 }
38 }

```

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         private static readonly EqualityComparer<TLink> _equalityComparer =
24             ↪ EqualityComparer<TLink>.Default;
25
26         private const int Length = 3;
27
28         public readonly TLink Index;
29         public readonly TLink Source;
30         public readonly TLink Target;
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public Link(params TLink[] values) => SetValues(values, out Index, out Source, out
34             ↪ Target);
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public Link(IList<TLink> values) => SetValues(values, out Index, out Source, out Target);
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         public Link(object other)
41         {
42             if (other is Link<TLink> otherLink)
43             {
44                 SetValues(ref otherLink, out Index, out Source, out Target);
45             }
46             else if (other is IList<TLink> otherList)
47             {
48                 SetValues(otherList, out Index, out Source, out Target);
49             }
50             else
51             {
52                 throw new NotSupportedException();
53             }
54         }
55
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

54 public Link(ref Link<TLink> other) => SetValues(ref other, out Index, out Source, out
55     ↪ Target);
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 public Link(TLink index, TLink source, TLink target)
59 {
60     Index = index;
61     Source = source;
62     Target = target;
63 }
64
65 [MethodImpl(MethodImplOptions.AggressiveInlining)]
66 private static void SetValues(ref Link<TLink> other, out TLink index, out TLink source,
67     ↪ out TLink target)
68 {
69     index = other.Index;
70     source = other.Source;
71     target = other.Target;
72 }
73
74 [MethodImpl(MethodImplOptions.AggressiveInlining)]
75 private static void SetValues(ICollection<TLink> values, out TLink index, out TLink source,
76     ↪ out TLink target)
77 {
78     switch (values.Count)
79     {
80         case 3:
81             index = values[0];
82             source = values[1];
83             target = values[2];
84             break;
85         case 2:
86             index = values[0];
87             source = values[1];
88             target = default;
89             break;
90         case 1:
91             index = values[0];
92             source = default;
93             target = default;
94             break;
95         default:
96             index = default;
97             source = default;
98             target = default;
99             break;
100     }
101 }
102
103 [MethodImpl(MethodImplOptions.AggressiveInlining)]
104 public override int GetHashCode() => (Index, Source, Target).GetHashCode();
105
106 [MethodImpl(MethodImplOptions.AggressiveInlining)]
107 public bool IsNull() => _equalityComparer.Equals(Index, _constants.Null)
108     && _equalityComparer.Equals(Source, _constants.Null)
109     && _equalityComparer.Equals(Target, _constants.Null);
110
111 [MethodImpl(MethodImplOptions.AggressiveInlining)]
112 public override bool Equals(object other) => other is Link<TLink> &&
113     ↪ Equals((Link<TLink>)other);
114
115 [MethodImpl(MethodImplOptions.AggressiveInlining)]
116 public bool Equals(Link<TLink> other) => _equalityComparer.Equals(Index, other.Index)
117     && _equalityComparer.Equals(Source, other.Source)
118     && _equalityComparer.Equals(Target, other.Target);
119
120 [MethodImpl(MethodImplOptions.AggressiveInlining)]
121 public static string ToString(TLink index, TLink source, TLink target) => $"{index}:
122     ↪ {source}->{target}";
123
124 [MethodImpl(MethodImplOptions.AggressiveInlining)]
125 public static string ToString(TLink source, TLink target) => $"{source}->{target}";
126
127 [MethodImpl(MethodImplOptions.AggressiveInlining)]
128 public static implicit operator TLink[] (Link<TLink> link) => link.ToArray();
129
130 [MethodImpl(MethodImplOptions.AggressiveInlining)]
131 public static implicit operator Link<TLink> (TLink[] linkArray) => new
132     ↪ Link<TLink>(linkArray);

```

```

128 [MethodImpl(MethodImplOptions.AggressiveInlining)]
129 public override string ToString() => _equalityComparer.Equals(Index, _constants.Null) ?
    ↳ ToString(Source, Target) : ToString(Index, Source, Target);
130
131 #region IList
132
133 public int Count
134 {
135     [MethodImpl(MethodImplOptions.AggressiveInlining)]
136     get => Length;
137 }
138
139 public bool IsReadOnly
140 {
141     [MethodImpl(MethodImplOptions.AggressiveInlining)]
142     get => true;
143 }
144
145 public TLink this[int index]
146 {
147     [MethodImpl(MethodImplOptions.AggressiveInlining)]
148     get
149     {
150         Ensure.OnDebug.ArgumentInRange(index, new Range<int>(0, Length - 1),
151             ↳ nameof(index));
152         if (index == _constants.IndexPart)
153         {
154             return Index;
155         }
156         if (index == _constants.SourcePart)
157         {
158             return Source;
159         }
160         if (index == _constants.TargetPart)
161         {
162             return Target;
163         }
164         throw new NotSupportedException(); // Impossible path due to
165             ↳ Ensure.ArgumentInRange
166     }
167     [MethodImpl(MethodImplOptions.AggressiveInlining)]
168     set => throw new NotSupportedException();
169 }
170
171 [MethodImpl(MethodImplOptions.AggressiveInlining)]
172 IEnumerator IEnumerable.GetEnumerator() => GetEnumerator();
173
174 [MethodImpl(MethodImplOptions.AggressiveInlining)]
175 public IEnumerator<TLink> GetEnumerator()
176 {
177     yield return Index;
178     yield return Source;
179     yield return Target;
180 }
181
182 [MethodImpl(MethodImplOptions.AggressiveInlining)]
183 public void Add(TLink item) => throw new NotSupportedException();
184
185 [MethodImpl(MethodImplOptions.AggressiveInlining)]
186 public void Clear() => throw new NotSupportedException();
187
188 [MethodImpl(MethodImplOptions.AggressiveInlining)]
189 public bool Contains(TLink item) => IndexOf(item) >= 0;
190
191 [MethodImpl(MethodImplOptions.AggressiveInlining)]
192 public void CopyTo(TLink[] array, int arrayIndex)
193 {
194     Ensure.OnDebug.ArgumentNotNull(array, nameof(array));
195     Ensure.OnDebug.ArgumentInRange(arrayIndex, new Range<int>(0, array.Length - 1),
196         ↳ nameof(arrayIndex));
197     if (arrayIndex + Length > array.Length)
198     {
199         throw new InvalidOperationException();
200     }
201     array[arrayIndex++] = Index;
202     array[arrayIndex++] = Source;
203     array[arrayIndex] = Target;
204 }

```

```

203 [MethodImpl(MethodImplOptions.AggressiveInlining)]
204 public bool Remove(TLink item) => Throw.A.NotSupportedExceptionAndReturn<bool>();
205
206 [MethodImpl(MethodImplOptions.AggressiveInlining)]
207 public int IndexOf(TLink item)
208 {
209     if (_equalityComparer.Equals(Index, item))
210     {
211         return _constants.IndexPart;
212     }
213     if (_equalityComparer.Equals(Source, item))
214     {
215         return _constants.SourcePart;
216     }
217     if (_equalityComparer.Equals(Target, item))
218     {
219         return _constants.TargetPart;
220     }
221     return -1;
222 }
223
224 [MethodImpl(MethodImplOptions.AggressiveInlining)]
225 public void Insert(int index, TLink item) => throw new NotSupportedException();
226
227 [MethodImpl(MethodImplOptions.AggressiveInlining)]
228 public void RemoveAt(int index) => throw new NotSupportedException();
229
230 [MethodImpl(MethodImplOptions.AggressiveInlining)]
231 public static bool operator ==(Link<TLink> left, Link<TLink> right) =>
    ↪ left.Equals(right);
232
233 [MethodImpl(MethodImplOptions.AggressiveInlining)]
234 public static bool operator !=(Link<TLink> left, Link<TLink> right) => !(left == right);
235
236 #endregion
237 }
238 }

```

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) =>
            ↪ Point<TLink>.IsFullPoint(link);
11
12        [MethodImpl(MethodImplOptions.AggressiveInlining)]
13        public static bool IsPartialPoint<TLink>(this Link<TLink> link) =>
            ↪ Point<TLink>.IsPartialPoint(link);
14    }
15 }

```

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    }
22 }
```

```

20 public TLink RootAsSource;
21 public TLink RootAsTarget;
22 public TLink LastFreeLink;
23 public TLink Reserved8;
24
25 [MethodImpl(MethodImplOptions.AggressiveInlining)]
26 public override bool Equals(object obj) => obj is LinksHeader<TLink> linksHeader ?
    ↳ Equals(linksHeader) : false;
27
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 public bool Equals(LinksHeader<TLink> other)
30     => _equalityComparer.Equals(AllocatedLinks, other.AllocatedLinks)
31     && _equalityComparer.Equals(ReservedLinks, other.ReservedLinks)
32     && _equalityComparer.Equals(FreeLinks, other.FreeLinks)
33     && _equalityComparer.Equals(FirstFreeLink, other.FirstFreeLink)
34     && _equalityComparer.Equals(RootAsSource, other.RootAsSource)
35     && _equalityComparer.Equals(RootAsTarget, other.RootAsTarget)
36     && _equalityComparer.Equals(LastFreeLink, other.LastFreeLink)
37     && _equalityComparer.Equals(Reserved8, other.Reserved8);
38
39 [MethodImpl(MethodImplOptions.AggressiveInlining)]
40 public override int GetHashCode() => (AllocatedLinks, ReservedLinks, FreeLinks,
    ↳ FirstFreeLink, RootAsSource, RootAsTarget, LastFreeLink, Reserved8).GetHashCode();
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 public static bool operator ==(LinksHeader<TLink> left, LinksHeader<TLink> right) =>
    ↳ left.Equals(right);
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 public static bool operator !=(LinksHeader<TLink> left, LinksHeader<TLink> right) =>
    ↳ !(left == right);
47 }
48 }

```

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 }

```

```

42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected abstract bool FirstIsToLeftOfSecond(TLink source, TLink target, TLink
    ↪ rootSource, TLink rootTarget);
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
    ↪ AsRef<LinksHeader<TLink>>(Header);
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
    ↪ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
    ↪ _addressToInt64Converter.Convert(link)));
50
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
    ↪ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
    ↪ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
56 {
57     ref var link = ref GetLinkDataPartReference(linkIndex);
58     return new Link<TLink>(linkIndex, link.Source, link.Target);
59 }
60
61 [MethodImpl(MethodImplOptions.AggressiveInlining)]
62 protected override bool FirstIsToLeftOfSecond(TLink first, TLink second)
63 {
64     ref var firstLink = ref GetLinkDataPartReference(first);
65     ref var secondLink = ref GetLinkDataPartReference(second);
66     return FirstIsToLeftOfSecond(firstLink.Source, firstLink.Target,
    ↪ secondLink.Source, secondLink.Target);
67 }
68
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
71 {
72     ref var firstLink = ref 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)) //
123             ↪ node.Key < root.Key
124         {
125             root = GetLeftOrDefault(root);
126         }
127         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
128             ↪ node.Key > root.Key
129         {
130             root = GetRightOrDefault(root);
131         }
132         else // node.Key == root.Key
133         {
134             return root;
135         }
136     }
137     return Zero;
138 }
139
140 // TODO: Return indices range instead of references count
141 [MethodImpl(MethodImplOptions.AggressiveInlining)]
142 public TLink CountUsages(TLink link)
143 {
144     var root = GetTreeRoot();
145     var total = GetSize(root);
146     var totalRightIgnore = Zero;
147     while (!EqualToZero(root))
148     {
149         var @base = GetBasePartValue(root);
150         if (LessOrEqualThan(@base, link))
151         {
152             root = GetRightOrDefault(root);
153         }
154         else
155         {
156             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
157             root = GetLeftOrDefault(root);
158         }
159     }
160     root = GetTreeRoot();
161     var totalLeftIgnore = Zero;
162     while (!EqualToZero(root))
163     {
164         var @base = GetBasePartValue(root);
165         if (GreaterOrEqualThan(@base, link))
166         {
167             root = GetLeftOrDefault(root);
168         }
169         else
170         {
171             totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
172             root = GetRightOrDefault(root);
173         }
174     }
175     return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
176 }
177
178 [MethodImpl(MethodImplOptions.AggressiveInlining)]
179 public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
180     ↪ EachUsageCore(@base, GetTreeRoot(), handler);
181
182 // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
183     ↪ low-level MSIL stack.
184 [MethodImpl(MethodImplOptions.AggressiveInlining)]
185 private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
186 {
187     var @continue = Continue;

```

```

184         if (EqualToZero(link))
185         {
186             return @continue;
187         }
188         var linkBasePart = GetBasePartValue(link);
189         var @break = Break;
190         if (GreaterThan(linkBasePart, @base))
191         {
192             if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
193             {
194                 return @break;
195             }
196         }
197         else if (LessThan(linkBasePart, @base))
198         {
199             if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
200             {
201                 return @break;
202             }
203         }
204         else //if (linkBasePart == @base)
205         {
206             if (AreEqual(handler(GetLinkValues(link)), @break))
207             {
208                 return @break;
209             }
210             if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
211             {
212                 return @break;
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 }

```

1.32 ./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         {

```

```

26     LinksDataParts = linksDataParts;
27     LinksIndexParts = linksIndexParts;
28     Header = header;
29     Break = constants.Break;
30     Continue = constants.Continue;
31 }
32
33 [MethodImpl(MethodImplOptions.AggressiveInlining)]
34 protected abstract TLink GetTreeRoot();
35
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 protected abstract TLink GetBasePartValue(TLink link);
38
39 [MethodImpl(MethodImplOptions.AggressiveInlining)]
40 protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
    ↪ rootSource, TLink rootTarget);
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
    ↪ rootSource, TLink rootTarget);
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
    ↪ AsRef<LinksHeader<TLink>>(Header);
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
    ↪ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
    ↪ _addressToInt64Converter.Convert(link)));
50
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
    ↪ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
    ↪ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
56 {
57     ref var link = ref GetLinkDataPartReference(linkIndex);
58     return new Link<TLink>(linkIndex, link.Source, link.Target);
59 }
60
61 [MethodImpl(MethodImplOptions.AggressiveInlining)]
62 protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
63 {
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
104     ↪ broken)
105 }
106
107 /// <summary>
108 /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
109 ↪ (концом).
110 /// </summary>
111 /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
112 /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
113 /// <returns>Индекс искомой связи.</returns>
114 [MethodImpl(MethodImplOptions.AggressiveInlining)]
115 public TLink Search(TLink source, TLink target)
116 {
117     var root = GetTreeRoot();
118     while (!EqualToZero(root))
119     {
120         ref var rootLink = ref GetLinkDataPartReference(root);
121         var rootSource = rootLink.Source;
122         var rootTarget = rootLink.Target;
123         if (FirstIsToTheLeftOfSecond(source, target, rootSource, rootTarget)) //
124             ↪ node.Key < root.Key
125         {
126             root = GetLeftOrDefault(root);
127         }
128         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
129             ↪ node.Key > root.Key
130         {
131             root = GetRightOrDefault(root);
132         }
133         else // node.Key == root.Key
134         {
135             return root;
136         }
137     }
138     return Zero;
139 }
140
141 // TODO: Return indices range instead of references count
142 [MethodImpl(MethodImplOptions.AggressiveInlining)]
143 public TLink CountUsages(TLink link)
144 {
145     var root = GetTreeRoot();
146     var total = GetSize(root);
147     var totalRightIgnore = Zero;
148     while (!EqualToZero(root))
149     {
150         var @base = GetBasePartValue(root);
151         if (LessOrEqualThan(@base, link))
152         {
153             root = GetRightOrDefault(root);
154         }
155         else
156         {
157             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
158             root = GetLeftOrDefault(root);
159         }
160     }
161     root = GetTreeRoot();
162     var totalLeftIgnore = Zero;
163     while (!EqualToZero(root))
164     {
165         var @base = GetBasePartValue(root);
166         if (GreaterOrEqualThan(@base, link))
167         {
168             root = GetLeftOrDefault(root);
169         }
170         else
171         {
172             totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
173         }
174     }
175 }

```

```

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

```

1.33 ./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)]

```



```

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

```

1.34 ./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> :
    ↳ ExternalLinksSizeBalancedTreeMethodsBase<TLink>
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public ExternalLinksSourcesSizeBalancedTreeMethods(LinksConstants<TLink> constants,
    ↳ byte* linksDataParts, byte* linksIndexParts, byte* header) : base(constants,
    ↳ linksDataParts, linksIndexParts, header) { }

```

```

11     [MethodImpl(MethodImplOptions.AggressiveInlining)]
12     protected override ref TLink GetLeftReference(TLink node) => ref
13     ↪ GetLinkIndexPartReference(node).LeftAsSource;
14
15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     protected override ref TLink GetRightReference(TLink node) => ref
17     ↪ GetLinkIndexPartReference(node).RightAsSource;
18
19     [MethodImpl(MethodImplOptions.AggressiveInlining)]
20     protected override TLink GetLeft(TLink node) =>
21     ↪ GetLinkIndexPartReference(node).LeftAsSource;
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected override TLink GetRight(TLink node) =>
25     ↪ GetLinkIndexPartReference(node).RightAsSource;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override void SetLeft(TLink node, TLink left) =>
29     ↪ GetLinkIndexPartReference(node).LeftAsSource = left;
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override void SetRight(TLink node, TLink right) =>
33     ↪ GetLinkIndexPartReference(node).RightAsSource = right;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override TLink GetSize(TLink node) =>
37     ↪ GetLinkIndexPartReference(node).SizeAsSource;
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 FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
52     ↪ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
53     ↪ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
57     ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
58     ↪ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override void ClearNode(TLink node)
62     {
63         ref var link = ref GetLinkIndexPartReference(node);
64         link.LeftAsSource = Zero;
65         link.RightAsSource = Zero;
66         link.SizeAsSource = Zero;
67     }
68 }

```

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)]

```

```

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

```

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
20

```

```

15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     protected override ref TLink GetRightReference(TLink node) => ref
    ↪ GetLinkIndexPartReference(node).RightAsTarget;
17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     protected override TLink GetLeft(TLink node) =>
    ↪ GetLinkIndexPartReference(node).LeftAsTarget;
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override TLink GetRight(TLink node) =>
    ↪ GetLinkIndexPartReference(node).RightAsTarget;
23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override void SetLeft(TLink node, TLink left) =>
    ↪ GetLinkIndexPartReference(node).LeftAsTarget = left;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override void SetRight(TLink node, TLink right) =>
    ↪ GetLinkIndexPartReference(node).RightAsTarget = right;
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     protected override TLink GetSize(TLink node) =>
    ↪ GetLinkIndexPartReference(node).SizeAsTarget;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override void SetSize(TLink node, TLink size) =>
    ↪ GetLinkIndexPartReference(node).SizeAsTarget = size;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override TLink GetTreeRoot() => GetHeaderReference().RootAsTarget;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override TLink GetBasePartValue(TLink link) =>
    ↪ GetLinkDataPartReference(link).Target;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override bool FirstIsToLeftOfSecond(TLink firstSource, TLink firstTarget,
    ↪ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
    ↪ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
    ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
    ↪ (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override void ClearNode(TLink node)
50     {
51         ref var link = ref GetLinkIndexPartReference(node);
52         link.LeftAsTarget = Zero;
53         link.RightAsTarget = Zero;
54         link.SizeAsTarget = Zero;
55     }
56 }
57 }

```

1.37 ./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> :
    ↪ RecursionlessSizeBalancedTreeMethods<TLink>, ILinksTreeMethods<TLink>
14     {
15         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
    ↪ UncheckedConverter<TLink, long>.Default;
16
17         protected readonly TLink Break;
18         protected readonly TLink Continue;
19         protected readonly byte* LinksDataParts;
20         protected readonly byte* LinksIndexParts;

```

```

21     protected readonly byte* Header;
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected InternalLinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<TLink>
    ↪ constants, byte* linksDataParts, byte* linksIndexParts, byte* header)
25     {
26         LinksDataParts = linksDataParts;
27         LinksIndexParts = linksIndexParts;
28         Header = header;
29         Break = constants.Break;
30         Continue = constants.Continue;
31     }
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected abstract TLink GetTreeRoot(TLink link);
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected abstract TLink GetBasePartValue(TLink link);
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected abstract TLink GetKeyPartValue(TLink link);
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
    ↪ AsRef<RawLinkDataPart<TLink>>(LinksDataParts + (RawLinkDataPart<TLink>.SizeInBytes *
    ↪ _addressToInt64Converter.Convert(link)));
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
    ↪ ref AsRef<RawLinkIndexPart<TLink>>(LinksIndexParts +
    ↪ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override bool FirstIsToLeftOfSecond(TLink first, TLink second) =>
    ↪ LessThan(GetKeyPartValue(first), GetKeyPartValue(second));
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
    ↪ GreaterThan(GetKeyPartValue(first), GetKeyPartValue(second));
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
56     {
57         ref var link = ref GetLinkDataPartReference(linkIndex);
58         return new Link<TLink>(linkIndex, link.Source, link.Target);
59     }
60
61     public TLink this[TLink link, TLink index]
62     {
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         get
65         {
66             var root = GetTreeRoot(link);
67             if (GreaterOrEqualThan(index, GetSize(root)))
68             {
69                 return Zero;
70             }
71             while (!EqualToZero(root))
72             {
73                 var left = GetLeftOrDefault(root);
74                 var leftSize = GetSizeOrZero(left);
75                 if (LessThan(index, leftSize))
76                 {
77                     root = left;
78                     continue;
79                 }
80                 if (AreEqual(index, leftSize))
81                 {
82                     return root;
83                 }
84                 root = GetRightOrDefault(root);
85                 index = Subtract(index, Increment(leftSize));
86             }
87             return Zero; // TODO: Impossible situation exception (only if tree structure
    ↪ broken)
88         }
89     }
90
91     /// <summary>

```

```

92  /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
93  ↪ (концом).
94  /// </summary>
95  /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
96  /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
97  /// <returns>Индекс искомой связи.</returns>
98  [MethodImpl(MethodImplOptions.AggressiveInlining)]
99  public abstract TLink Search(TLink source, TLink target);
100
101  [MethodImpl(MethodImplOptions.AggressiveInlining)]
102  protected TLink SearchCore(TLink root, TLink key)
103  {
104      while (!EqualToZero(root))
105      {
106          var rootKey = GetKeyPartValue(root);
107          if (LessThan(key, rootKey)) // node.Key < root.Key
108          {
109              root = GetLeftOrDefault(root);
110          }
111          else if (GreaterThan(key, rootKey)) // node.Key > root.Key
112          {
113              root = GetRightOrDefault(root);
114          }
115          else // node.Key == root.Key
116          {
117              return root;
118          }
119      }
120      return Zero;
121  }
122
123  // TODO: Return indices range instead of references count
124  [MethodImpl(MethodImplOptions.AggressiveInlining)]
125  public TLink CountUsages(TLink link) => GetSizeOrZero(GetTreeRoot(link));
126
127  [MethodImpl(MethodImplOptions.AggressiveInlining)]
128  public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
129  ↪ EachUsageCore(@base, GetTreeRoot(@base), handler);
130
131  // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
132  ↪ low-level MSIL stack.
133  [MethodImpl(MethodImplOptions.AggressiveInlining)]
134  private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
135  {
136      var @continue = Continue;
137      if (EqualToZero(link))
138      {
139          return @continue;
140      }
141      var @break = Break;
142      if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
143      {
144          return @break;
145      }
146      if (AreEqual(handler(GetLinkValues(link)), @break))
147      {
148          return @break;
149      }
150      if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
151      {
152          return @break;
153      }
154      return @continue;
155  }
156
157  [MethodImpl(MethodImplOptions.AggressiveInlining)]
158  protected override void PrintNodeValue(TLink node, StringBuilder sb)
159  {
160      ref var link = ref GetLinkDataPartReference(node);
161      sb.Append(' ');
162      sb.Append(link.Source);
163      sb.Append('-');
164      sb.Append('>');
165      sb.Append(link.Target);
166  }
167  }
168  }

```

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 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         public TLink this[TLink link, TLink index]
71         {
72             [MethodImpl(MethodImplOptions.AggressiveInlining)]
73             get
74             {
75                 var root = GetTreeRoot(link);
76                 if (GreaterOrEqualThan(index, GetSize(root)))
77                 {
78                     return Zero;
79                 }
80             }
81         }
82     }
83 }
```

```

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

```



```

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> :
13         ↳ RelativeCircularDoublyLinkedListMethods<TLink>
14     {
15         private static readonly UncheckedConverter<TLink, long> _addressToInt64Converter =
16             ↳ UncheckedConverter<TLink, long>.Default;
17         private readonly byte* _linksDataParts;
18         private readonly byte* _linksIndexParts;
19         protected readonly TLink Break;
20         protected readonly TLink Continue;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public InternalLinksSourcesLinkedListMethods(LinksConstants<TLink> constants, byte*
24             ↳ linksDataParts, byte* linksIndexParts)
25         {
26             _linksDataParts = linksDataParts;
27             _linksIndexParts = linksIndexParts;
28             Break = constants.Break;
29             Continue = constants.Continue;
30         }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected virtual ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
34             ↳ AsRef<RawLinkDataPart<TLink>>(_linksDataParts + (RawLinkDataPart<TLink>.SizeInBytes
35             ↳ * _addressToInt64Converter.Convert(link)));
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected virtual ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
39             ↳ ref AsRef<RawLinkIndexPart<TLink>>(_linksIndexParts +
40             ↳ (RawLinkIndexPart<TLink>.SizeInBytes * _addressToInt64Converter.Convert(link)));
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override TLink GetFirst(TLink head) =>
44             ↳ GetLinkIndexPartReference(head).RootAsSource;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetLast(TLink head)
48         {
49             var first = GetLinkIndexPartReference(head).RootAsSource;
50             if (EqualToZero(first))
51             {
52                 return first;
53             }
54             else
55             {
56                 return GetPrevious(first);
57             }
58         }
59     }
60 }

```

```

51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected override TLink GetPrevious(TLink element) =>
53     ↪ GetLinkIndexPartReference(element).LeftAsSource;
54
55 [MethodImpl(MethodImplOptions.AggressiveInlining)]
56 protected override TLink GetNext(TLink element) =>
57     ↪ GetLinkIndexPartReference(element).RightAsSource;
58
59 [MethodImpl(MethodImplOptions.AggressiveInlining)]
60 protected override TLink GetSize(TLink head) =>
61     ↪ GetLinkIndexPartReference(head).SizeAsSource;
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 protected override void SetFirst(TLink head, TLink element) =>
65     ↪ GetLinkIndexPartReference(head).RootAsSource = element;
66
67 [MethodImpl(MethodImplOptions.AggressiveInlining)]
68 protected override void SetLast(TLink head, TLink element)
69 {
70     //var first = GetLinkIndexPartReference(head).RootAsSource;
71     //if (EqualToZero(first))
72     //{
73     //    SetFirst(head, element);
74     //}
75     //else
76     //{
77     //    SetPrevious(first, element);
78     //}
79 }
80
81 [MethodImpl(MethodImplOptions.AggressiveInlining)]
82 protected override void SetPrevious(TLink element, TLink previous) =>
83     ↪ GetLinkIndexPartReference(element).LeftAsSource = previous;
84
85 [MethodImpl(MethodImplOptions.AggressiveInlining)]
86 protected override void SetNext(TLink element, TLink next) =>
87     ↪ GetLinkIndexPartReference(element).RightAsSource = next;
88
89 [MethodImpl(MethodImplOptions.AggressiveInlining)]
90 protected override void SetSize(TLink head, TLink size) =>
91     ↪ GetLinkIndexPartReference(head).SizeAsSource = size;
92
93 [MethodImpl(MethodImplOptions.AggressiveInlining)]
94 public TLink CountUsages(TLink head) => GetSize(head);
95
96 [MethodImpl(MethodImplOptions.AggressiveInlining)]
97 protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
98 {
99     ref var link = ref GetLinkDataPartReference(linkIndex);
100     return new Link<TLink>(linkIndex, link.Source, link.Target);
101 }
102
103 [MethodImpl(MethodImplOptions.AggressiveInlining)]
104 public TLink EachUsage(TLink source, Func<IList<TLink>, TLink> handler)
105 {
106     var @continue = Continue;
107     var @break = Break;
108     var current = GetFirst(source);
109     var first = current;
110     while (!EqualToZero(current))
111     {
112         if (AreEqual(handler(GetLinkValues(current)), @break))
113         {
114             return @break;
115         }
116         current = GetNext(current);
117         if (AreEqual(current, first))
118         {
119             return @continue;
120         }
121     }
122     return @continue;
123 }
124
125 }
126
127 }

```

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)]
44         protected override void SetSize(TLink node, TLink size) =>
45             ↳ GetLinkIndexPartReference(node).SizeAsSource = size;
46
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         protected override TLink GetTreeRoot(TLink link) =>
49             ↳ GetLinkIndexPartReference(link).RootAsSource;
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override TLink GetBasePartValue(TLink link) =>
53             ↳ GetLinkDataPartReference(link).Source;
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override TLink GetKeyPartValue(TLink link) =>
57             ↳ GetLinkDataPartReference(link).Target;
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(TLink node)
61         {
62             ref var link = ref GetLinkIndexPartReference(node);
63             link.LeftAsSource = Zero;
64             link.RightAsSource = Zero;
65             link.SizeAsSource = Zero;
66         }
67
68         public override TLink Search(TLink source, TLink target) =>
69             ↳ SearchCore(GetTreeRoot(source), target);
70     }
71 }

```

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)]
48         protected override TLink GetTreeRoot(TLink link) =>
49             ↳ GetLinkIndexPartReference(link).RootAsSource;
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         protected override TLink GetBasePartValue(TLink link) =>
53             ↳ GetLinkDataPartReference(link).Source;
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected override TLink GetKeyPartValue(TLink link) =>
57             ↳ GetLinkDataPartReference(link).Target;
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         protected override void ClearNode(TLink node)
61         {
62             ref var link = ref GetLinkIndexPartReference(node);
63             link.LeftAsSource = Zero;
64             link.RightAsSource = Zero;
65             link.SizeAsSource = Zero;
66         }
67
68         public override TLink Search(TLink source, TLink target) =>
69             ↳ SearchCore(GetTreeRoot(source), target);
70     }
71 }

```

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     {

```

```

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

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

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

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

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

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

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

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

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

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

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

41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override TLink GetKeyPartValue(TLink link) =>
    ↳ GetLinkDataPartReference(link).Source;

44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override void ClearNode(TLink node)
47     {
48         ref var link = ref GetLinkIndexPartReference(node);
49         link.LeftAsTarget = Zero;
50         link.RightAsTarget = Zero;
51         link.SizeAsTarget = Zero;
52     }

53
54     public override TLink Search(TLink source, TLink target) =>
    ↳ SearchCore(GetTreeRoot(target), source);

55 }
56 }

```

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> :
    ↳ InternalLinksSizeBalancedTreeMethodsBase<TLink>
8      {
9          [MethodImpl(MethodImplOptions.AggressiveInlining)]
10         public InternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink> constants,
    ↳ byte* linksDataParts, byte* linksIndexParts, byte* header) : base(constants,
    ↳ linksDataParts, linksIndexParts, header) { }

```

```

12     [MethodImpl(MethodImplOptions.AggressiveInlining)]
13     protected override ref TLink GetLeftReference(TLink node) => ref
    ↪ GetLinkIndexPartReference(node).LeftAsTarget;
14
15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     protected override ref TLink GetRightReference(TLink node) => ref
    ↪ GetLinkIndexPartReference(node).RightAsTarget;
17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     protected override TLink GetLeft(TLink node) =>
    ↪ GetLinkIndexPartReference(node).LeftAsTarget;
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override TLink GetRight(TLink node) =>
    ↪ GetLinkIndexPartReference(node).RightAsTarget;
23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override void SetLeft(TLink node, TLink left) =>
    ↪ GetLinkIndexPartReference(node).LeftAsTarget = left;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override void SetRight(TLink node, TLink right) =>
    ↪ GetLinkIndexPartReference(node).RightAsTarget = right;
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     protected override TLink GetSize(TLink node) =>
    ↪ GetLinkIndexPartReference(node).SizeAsTarget;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override void SetSize(TLink node, TLink size) =>
    ↪ GetLinkIndexPartReference(node).SizeAsTarget = size;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override TLink GetTreeRoot(TLink link) =>
    ↪ GetLinkIndexPartReference(link).RootAsTarget;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override TLink GetBasePartValue(TLink link) =>
    ↪ GetLinkDataPartReference(link).Target;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override TLink GetKeyPartValue(TLink link) =>
    ↪ GetLinkDataPartReference(link).Source;
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override void ClearNode(TLink node)
47     {
48         ref var link = ref GetLinkIndexPartReference(node);
49         link.LeftAsTarget = Zero;
50         link.RightAsTarget = Zero;
51         link.SizeAsTarget = Zero;
52     }
53
54     public override TLink Search(TLink source, TLink target) =>
    ↪ SearchCore(GetTreeRoot(target), source);
55 }
56 }

```

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(string dataMemory, string indexMemory) : this(new
    ↳ FileMappedResizableDirectMemory(dataMemory), new
    ↳ FileMappedResizableDirectMemory(indexMemory)) { }
23
24 [MethodImpl(MethodImplOptions.AggressiveInlining)]
25 public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory) : this(dataMemory, indexMemory, DefaultLinksSizeStep) { }
26
27 [MethodImpl(MethodImplOptions.AggressiveInlining)]
28 public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
    ↳ memoryReservationStep, Default<LinksConstants<TLink>>.Instance,
    ↳ IndexTreeType.Default, useLinkedList: true) { }
29
30 [MethodImpl(MethodImplOptions.AggressiveInlining)]
31 public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants) :
    ↳ this(dataMemory, indexMemory, memoryReservationStep, constants,
    ↳ IndexTreeType.Default, useLinkedList: true) { }
32
33 [MethodImpl(MethodImplOptions.AggressiveInlining)]
34 public SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants,
    ↳ IndexTreeType indexTreeType, bool useLinkedList) : base(dataMemory, indexMemory,
    ↳ memoryReservationStep, constants, useLinkedList)
35 {
36     if (indexTreeType == IndexTreeType.SizeBalancedTree)
37     {
38         _createInternalSourceTreeMethods = () => new
            ↳ InternalLinksSourcesSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
39         _createExternalSourceTreeMethods = () => new
            ↳ ExternalLinksSourcesSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
40         _createInternalTargetTreeMethods = () => new
            ↳ InternalLinksTargetsSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
41         _createExternalTargetTreeMethods = () => new
            ↳ ExternalLinksTargetsSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
42     }
43     else
44     {
45         _createInternalSourceTreeMethods = () => new
            ↳ InternalLinksSourcesRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
46         _createExternalSourceTreeMethods = () => new
            ↳ ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
47         _createInternalTargetTreeMethods = () => new
            ↳ InternalLinksTargetsRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
48         _createExternalTargetTreeMethods = () => new
            ↳ ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods<TLink>(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
49     }
50     Init(dataMemory, indexMemory);
51 }
52
53 [MethodImpl(MethodImplOptions.AggressiveInlining)]
54 protected override void SetPointers(IResizableDirectMemory dataMemory,
    ↳ IResizableDirectMemory indexMemory)
55 {
56     _linksDataParts = (byte*)dataMemory.Pointer;
57     _linksIndexParts = (byte*)indexMemory.Pointer;
58     _header = _linksIndexParts;
59     if (_useLinkedList)
60     {
61         InternalSourcesListMethods = new
            ↳ InternalLinksSourcesLinkedListMethods<TLink>(Constants, _linksDataParts,
            ↳ _linksIndexParts);
62     }
63     else
64     {
65         InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
66     }

```

```

67         ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
68         InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
69         ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
70         UnusedLinksListMethods = new UnusedLinksListMethods<TLink>(_linksDataParts, _header);
71     }
72
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     protected override void ResetPointers()
75     {
76         base.ResetPointers();
77         _linksDataParts = null;
78         _linksIndexParts = 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)]
87     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
88         ↪ => ref AsRef<RawLinkDataPart<TLink>>(_linksDataParts + (LinkDataPartSizeInBytes *
89         ↪ ConvertToInt64(linkIndex)));
90
91     [MethodImpl(MethodImplOptions.AggressiveInlining)]
92     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
93         ↪ linkIndex) => ref AsRef<RawLinkIndexPart<TLink>>(_linksIndexParts +
94         ↪ (LinkIndexPartSizeInBytes * ConvertToInt64(linkIndex)));
95 }
96 }

```

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;

```



```

46 protected ILinksTreeMethods<TLink> ExternalSourcesTreeMethods;
47 protected ILinksTreeMethods<TLink> InternalTargetsTreeMethods;
48 protected ILinksTreeMethods<TLink> ExternalTargetsTreeMethods;
49 // TODO: Возможно чтобы гарантированно проверять на то, является ли связь удалённой,
    ↳ нужно использовать не список а дерево, так как так можно быстрее проверить на
    ↳ наличие связи внутри
50 protected ILinksListMethods<TLink> UnusedLinksListMethods;
51
52 /// <summary>
53 /// Возвращает общее число связей находящихся в хранилище.
54 /// </summary>
55 protected virtual TLink Total
56 {
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     get
59     {
60         ref var header = ref GetHeaderReference();
61         return Subtract(header.AllocatedLinks, header.FreeLinks);
62     }
63 }
64
65 public virtual LinksConstants<TLink> Constants
66 {
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     get;
69 }
70
71 [MethodImpl(MethodImplOptions.AggressiveInlining)]
72 protected SplitMemoryLinksBase(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep, LinksConstants<TLink> constants, bool
    ↳ useLinkedList)
73 {
74     _dataMemory = dataMemory;
75     _indexMemory = indexMemory;
76     _dataMemoryReservationStepInBytes = memoryReservationStep * LinkDataPartSizeInBytes;
77     _indexMemoryReservationStepInBytes = memoryReservationStep *
    ↳ LinkIndexPartSizeInBytes;
78     _useLinkedList = useLinkedList;
79     Constants = constants;
80 }
81
82 [MethodImpl(MethodImplOptions.AggressiveInlining)]
83 protected SplitMemoryLinksBase(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
    ↳ memoryReservationStep, Default<LinksConstants<TLink>>.Instance, useLinkedList: true)
    ↳ { }
84
85 [MethodImpl(MethodImplOptions.AggressiveInlining)]
86 protected virtual void Init(IResizableDirectMemory dataMemory, IResizableDirectMemory
    ↳ 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(IList<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;
161     var index = restrictions[constants.IndexPart];
162     if (restrictions.Count == 1)
163     {
164         if (AreEqual(index, any))
165         {
166             return Total;
167         }
168         return Exists(index) ? GetOne() : GetZero();
169     }
170     if (restrictions.Count == 2)
171     {
172         var value = restrictions[1];
173         if (AreEqual(index, any))
174         {
175             return Total; // Any - как отсутствие ограничения
176         }
177         var externalReferencesRange = constants.ExternalReferencesRange;
178         if (externalReferencesRange.HasValue &&
179             ↪ externalReferencesRange.Value.Contains(value))
180         {
181             return Add(ExternalSourcesTreeMethods.CountUsages(value),
182                 ↪ ExternalTargetsTreeMethods.CountUsages(value));
183         }
184         else
185         {
186             if (_useLinkedList)
187             {
188                 return Add(InternalSourcesListMethods.CountUsages(value),
189                     ↪ InternalTargetsTreeMethods.CountUsages(value));
190             }
191             else
192             {
193                 // ...
194             }
195         }
196     }
197 }

```

```

183         {
184             return Add(InternalSourcesTreeMethods.CountUsages(value),
185                 ↪ InternalTargetsTreeMethods.CountUsages(value));
186         }
187     }
188 }
189 else
190 {
191     if (!Exists(index))
192     {
193         return GetZero();
194     }
195     if (AreEqual(value, any))
196     {
197         return GetOne();
198     }
199     ref var storedLinkValue = ref GetLinkDataPartReference(index);
200     if (AreEqual(storedLinkValue.Source, value) ||
201         ↪ AreEqual(storedLinkValue.Target, value))
202     {
203         return GetOne();
204     }
205     return GetZero();
206 }
207 if (restrictions.Count == 3)
208 {
209     var externalReferencesRange = constants.ExternalReferencesRange;
210     var source = restrictions[constants.SourcePart];
211     var target = restrictions[constants.TargetPart];
212     if (AreEqual(index, any))
213     {
214         if (AreEqual(source, any) && AreEqual(target, any))
215         {
216             return Total;
217         }
218         else if (AreEqual(source, any))
219         {
220             if (externalReferencesRange.HasValue &&
221                 ↪ externalReferencesRange.Value.Contains(target))
222             {
223                 return ExternalTargetsTreeMethods.CountUsages(target);
224             }
225             else
226             {
227                 return InternalTargetsTreeMethods.CountUsages(target);
228             }
229         }
230         else if (AreEqual(target, any))
231         {
232             if (externalReferencesRange.HasValue &&
233                 ↪ externalReferencesRange.Value.Contains(source))
234             {
235                 return ExternalSourcesTreeMethods.CountUsages(source);
236             }
237             else
238             {
239                 if (_useLinkedList)
240                 {
241                     return InternalSourcesListMethods.CountUsages(source);
242                 }
243                 else
244                 {
245                     return InternalSourcesTreeMethods.CountUsages(source);
246                 }
247             }
248         }
249     }
250 }
251 else //if(source != Any && target != Any)
252 {
253     // Эквивалент Exists(source, target) => Count(Any, source, target) > 0
254     TLink link;
255     if (externalReferencesRange.HasValue)
256     {
257         if (externalReferencesRange.Value.Contains(source) &&
258             ↪ externalReferencesRange.Value.Contains(target))
259         {
260             link = ExternalSourcesTreeMethods.Search(source, target);
261         }
262     }
263 }

```

```

256         else if (externalReferencesRange.Value.Contains(source))
257         {
258             link = InternalTargetsTreeMethods.Search(source, target);
259         }
260         else if (externalReferencesRange.Value.Contains(target))
261         {
262             if (_useLinkedList)
263             {
264                 link = ExternalSourcesTreeMethods.Search(source, target);
265             }
266             else
267             {
268                 link = InternalSourcesTreeMethods.Search(source, target);
269             }
270         }
271         else
272         {
273             if (_useLinkedList ||
274                 ↪ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
275                 ↪ InternalTargetsTreeMethods.CountUsages(target)))
276             {
277                 link = InternalTargetsTreeMethods.Search(source, target);
278             }
279             else
280             {
281                 link = InternalSourcesTreeMethods.Search(source, target);
282             }
283         }
284     }
285     else
286     {
287         if (_useLinkedList ||
288             ↪ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
289             ↪ InternalTargetsTreeMethods.CountUsages(target)))
290         {
291             link = InternalTargetsTreeMethods.Search(source, target);
292         }
293         else
294         {
295             link = InternalSourcesTreeMethods.Search(source, target);
296         }
297     }
298     return AreEqual(link, constants.Null) ? GetZero() : GetOne();
299 }
300 }
301 else
302 {
303     if (!Exists(index))
304     {
305         return GetZero();
306     }
307     if (AreEqual(source, any) && AreEqual(target, any))
308     {
309         return GetOne();
310     }
311     ref var storedLinkValue = ref GetLinkDataPartReference(index);
312     if (!AreEqual(source, any) && !AreEqual(target, any))
313     {
314         if (AreEqual(storedLinkValue.Source, source) &&
315             ↪ AreEqual(storedLinkValue.Target, target))
316         {
317             return GetOne();
318         }
319         return GetZero();
320     }
321     var value = default(TLink);
322     if (AreEqual(source, any))
323     {
324         value = target;
325     }
326     if (AreEqual(target, any))
327     {
328         value = source;
329     }
330     if (AreEqual(storedLinkValue.Source, value) ||
331         ↪ AreEqual(storedLinkValue.Target, value))
332     {
333         return GetOne();
334     }

```

```

328     }
329     return GetZero();
330 }
331 }
332 throw new NotSupportedException("Другие размеры и способы ограничений не
    ↳ поддерживаются.");
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             return @break;
350         }
351         var @continue = constants.Continue;
352         var any = constants.Any;
353         var index = restrictions[constants.IndexPart];
354         if (restrictions.Count == 1)
355         {
356             if (AreEqual(index, any))
357             {
358                 return Each(handler, Array.Empty<TLink>());
359             }
360             if (!Exists(index))
361             {
362                 return @continue;
363             }
364             return handler(GetLinkStruct(index));
365         }
366         if (restrictions.Count == 2)
367         {
368             var value = restrictions[1];
369             if (AreEqual(index, any))
370             {
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))
449             {
450                 link = ExternalSourcesTreeMethods.Search(source, target);
451             }
452             else if (externalReferencesRange.Value.Contains(source))
453             {
454                 link = InternalTargetsTreeMethods.Search(source, target);
455             }
456             else if (externalReferencesRange.Value.Contains(target))
457             {
458                 if (_useLinkedList)
459                 {
460                     link = ExternalSourcesTreeMethods.Search(source, target);
461                 }
462                 else
463                 {
464                     link = InternalSourcesTreeMethods.Search(source, target);
465                 }
466             }
467             else
468             {
469                 if (_useLinkedList ||
470                     ↪ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
471                     ↪ InternalTargetsTreeMethods.CountUsages(target)))
472                 {
473                     link = InternalTargetsTreeMethods.Search(source, target);
474                 }
475                 else
476                 {

```

```

477         {
478             if (_useLinkedList ||
479                 ↪ GreaterThan(InternalSourcesTreeMethods.CountUsages(source),
480                 ↪ InternalTargetsTreeMethods.CountUsages(target)))
481             {
482                 link = InternalTargetsTreeMethods.Search(source, target);
483             }
484             else
485             {
486                 link = InternalSourcesTreeMethods.Search(source, target);
487             }
488             return AreEqual(link, constants.Null) ? @continue :
489                 ↪ handler(GetLinkStruct(link));
490         }
491     else
492     {
493         if (!Exists(index))
494         {
495             return @continue;
496         }
497         if (AreEqual(source, any) && AreEqual(target, any))
498         {
499             return handler(GetLinkStruct(index));
500         }
501         ref var storedLinkValue = ref GetLinkDataPartReference(index);
502         if (!AreEqual(source, any) && !AreEqual(target, any))
503         {
504             if (AreEqual(storedLinkValue.Source, source) &&
505                 AreEqual(storedLinkValue.Target, target))
506             {
507                 return handler(GetLinkStruct(index));
508             }
509             return @continue;
510         }
511         var value = default(TLink);
512         if (AreEqual(source, any))
513         {
514             value = target;
515         }
516         if (AreEqual(target, any))
517         {
518             value = source;
519         }
520         if (AreEqual(storedLinkValue.Source, value) ||
521             AreEqual(storedLinkValue.Target, value))
522         {
523             return handler(GetLinkStruct(index));
524         }
525         return @continue;
526     }
527 }
528 throw new NotSupportedException("Другие размеры и способы ограничений не
529     ↪ поддерживаются.");
530
531 /// <remarks>
532 /// TODO: Возможно можно перемещать значения, если указан индекс, но значение существует
533     ↪ в другом месте (но не в менеджере памяти, а в логике Links)
534 /// </remarks>
535 [MethodImpl(MethodImplOptions.AggressiveInlining)]
536 public virtual TLink Update(IList<TLink> restrictions, IList<TLink> substitution)
537 {
538     var constants = Constants;
539     var @null = constants.Null;
540     var externalReferencesRange = constants.ExternalReferencesRange;
541     var linkIndex = restrictions[constants.IndexPart];
542     ref var link = ref GetLinkDataPartReference(linkIndex);
543     var source = link.Source;
544     var target = link.Target;
545     ref var header = ref GetHeaderReference();
546     ref var rootAsSource = ref header.RootAsSource;
547     ref var rootAsTarget = ref header.RootAsTarget;
548     // Будет корректно работать только в том случае, если пространство выделенной связи
549     ↪ предварительно заполнено нулями
550     if (!AreEqual(source, @null))
551     {

```

```

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
598                     ↪ GetLinkIndexPartReference(source).RootAsSource, linkIndex);
599             }
600         }
601     }
602     if (!AreEqual(target, @null))
603     {
604         if (externalReferencesRange.HasValue &&
605             ↪ externalReferencesRange.Value.Contains(target))
606         {
607             ExternalTargetsTreeMethods.Attach(ref rootAsTarget, linkIndex);
608         }
609         else
610         {
611             InternalTargetsTreeMethods.Attach(ref
612                 ↪ GetLinkIndexPartReference(target).RootAsTarget, linkIndex);
613         }
614     }
615     return linkIndex;
616 }
617
618 /// <remarks>
619 /// TODO: Возможно нужно будет заполнение нулями, если внешнее API ими не заполняет
620 ↪ пространство
621 /// </remarks>
622 [MethodImpl(MethodImplOptions.AggressiveInlining)]
623 public virtual TLink Create(ICollection<TLink> restrictions)
624 {
625     ref var header = ref GetHeaderReference();
626     var freeLink = header.FirstFreeLink;

```



```

618         if (!AreEqual(freeLink, Constants.Null))
619         {
620             UnusedLinksListMethods.Detach(freeLink);
621         }
622     else
623     {
624         var maximumPossibleInnerReference = Constants.InternalReferencesRange.Maximum;
625         if (GreaterThan(header.AllocatedLinks, maximumPossibleInnerReference))
626         {
627             throw new LinksLimitReachedException<TLink>(maximumPossibleInnerReference);
628         }
629         if (GreaterOrEqualThan(header.AllocatedLinks, Decrement(header.ReservedLinks)))
630         {
631             _dataMemory.ReservedCapacity += _dataMemory.ReservationStepInBytes;
632             _indexMemory.ReservedCapacity += _indexMemory.ReservationStepInBytes;
633             SetPointers(_dataMemory, _indexMemory);
634             header = ref GetHeaderReference();
635             header.ReservedLinks = ConvertToAddress(_dataMemory.ReservedCapacity /
636                 ↳ LinkDataPartSizeInBytes);
637         }
638         freeLink = header.AllocatedLinks = Increment(header.AllocatedLinks);
639         _dataMemory.UsedCapacity += LinkDataPartSizeInBytes;
640         _indexMemory.UsedCapacity += LinkIndexPartSizeInBytes;
641     }
642     return freeLink;
643 }
644 [MethodImpl(MethodImplOptions.AggressiveInlining)]
645 public virtual void Delete(IList<TLink> restrictions)
646 {
647     ref var header = ref GetHeaderReference();
648     var link = restrictions[Constants.IndexPart];
649     if (LessThan(link, header.AllocatedLinks))
650     {
651         UnusedLinksListMethods.AttachAsFirst(link);
652     }
653     else if (AreEqual(link, header.AllocatedLinks))
654     {
655         header.AllocatedLinks = Decrement(header.AllocatedLinks);
656         _dataMemory.UsedCapacity -= LinkDataPartSizeInBytes;
657         _indexMemory.UsedCapacity -= LinkIndexPartSizeInBytes;
658         // Убираем все связи, находящиеся в списке свободных в конце файла, до тех пор,
659         ↳ пока не дойдём до первой существующей связи
660         // Позволяет оптимизировать количество выделенных связей (AllocatedLinks)
661         while (GreaterThan(header.AllocatedLinks, GetZero()) &&
662             ↳ IsUnusedLink(header.AllocatedLinks))
663         {
664             UnusedLinksListMethods.Detach(header.AllocatedLinks);
665             header.AllocatedLinks = Decrement(header.AllocatedLinks);
666             _dataMemory.UsedCapacity -= LinkDataPartSizeInBytes;
667             _indexMemory.UsedCapacity -= LinkIndexPartSizeInBytes;
668         }
669     }
670 }
671 [MethodImpl(MethodImplOptions.AggressiveInlining)]
672 public IList<TLink> GetLinkStruct(TLink linkIndex)
673 {
674     ref var link = ref GetLinkDataPartReference(linkIndex);
675     return new Link<TLink>(linkIndex, link.Source, link.Target);
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 [MethodImpl(MethodImplOptions.AggressiveInlining)]
689 protected virtual void ResetPointers()
690 {
691     InternalSourcesListMethods = null;
692     InternalSourcesTreeMethods = null;

```

```

692     ExternalSourcesTreeMethods = null;
693     InternalTargetsTreeMethods = null;
694     ExternalTargetsTreeMethods = null;
695     UnusedLinksListMethods = null;
696 }
697
698 [MethodImpl(MethodImplOptions.AggressiveInlining)]
699 protected abstract ref LinksHeader<TLink> GetHeaderReference();
700
701 [MethodImpl(MethodImplOptions.AggressiveInlining)]
702 protected abstract ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex);
703
704 [MethodImpl(MethodImplOptions.AggressiveInlining)]
705 protected abstract ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
    ↪ linkIndex);
706
707 [MethodImpl(MethodImplOptions.AggressiveInlining)]
708 protected virtual bool Exists(TLink link)
709     => GreaterOrEqualThan(link, Constants.InternalReferencesRange.Minimum)
710     && LessOrEqualThan(link, GetHeaderReference().AllocatedLinks)
711     && !IsUnusedLink(link);
712
713 [MethodImpl(MethodImplOptions.AggressiveInlining)]
714 protected virtual bool IsUnusedLink(TLink linkIndex)
715 {
716     if (!AreEqual(GetHeaderReference().FirstFreeLink, linkIndex)) // May be this check
    ↪ is not needed
717     {
718         // TODO: Reduce access to memory in different location (should be enough to use
    ↪ just linkIndexPart)
719         ref var linkDataPart = ref GetLinkDataPartReference(linkIndex);
720         ref var linkIndexPart = ref GetLinkIndexPartReference(linkIndex);
721         return AreEqual(linkIndexPart.SizeAsTarget, default) &&
    ↪ !AreEqual(linkDataPart.Source, default);
722     }
723     else
724     {
725         return true;
726     }
727 }
728
729 [MethodImpl(MethodImplOptions.AggressiveInlining)]
730 protected virtual TLink GetOne() => _one;
731
732 [MethodImpl(MethodImplOptions.AggressiveInlining)]
733 protected virtual TLink GetZero() => default;
734
735 [MethodImpl(MethodImplOptions.AggressiveInlining)]
736 protected virtual bool AreEqual(TLink first, TLink second) =>
    ↪ _equalityComparer.Equals(first, second);
737
738 [MethodImpl(MethodImplOptions.AggressiveInlining)]
739 protected virtual bool LessThan(TLink first, TLink second) => _comparer.Compare(first,
    ↪ second) < 0;
740
741 [MethodImpl(MethodImplOptions.AggressiveInlining)]
742 protected virtual bool LessOrEqualThan(TLink first, TLink second) =>
    ↪ _comparer.Compare(first, second) <= 0;
743
744 [MethodImpl(MethodImplOptions.AggressiveInlining)]
745 protected virtual bool GreaterThan(TLink first, TLink second) =>
    ↪ _comparer.Compare(first, second) > 0;
746
747 [MethodImpl(MethodImplOptions.AggressiveInlining)]
748 protected virtual bool GreaterOrEqualThan(TLink first, TLink second) =>
    ↪ _comparer.Compare(first, second) >= 0;
749
750 [MethodImpl(MethodImplOptions.AggressiveInlining)]
751 protected virtual long ConvertToInt64(TLink value) =>
    ↪ _addressToInt64Converter.Convert(value);
752
753 [MethodImpl(MethodImplOptions.AggressiveInlining)]
754 protected virtual TLink ConvertToAddress(long value) =>
    ↪ _int64ToAddressConverter.Convert(value);
755
756 [MethodImpl(MethodImplOptions.AggressiveInlining)]
757 protected virtual TLink Add(TLink first, TLink second) => Arithmetic<TLink>.Add(first,
    ↪ second);

```

```

758 [MethodImpl(MethodImplOptions.AggressiveInlining)]
759 protected virtual TLink Subtract(TLink first, TLink second) =>
760     ↳ Arithmetic<TLink>.Subtract(first, second);
761
762 [MethodImpl(MethodImplOptions.AggressiveInlining)]
763 protected virtual TLink Increment(TLink link) => Arithmetic<TLink>.Increment(link);
764
765 [MethodImpl(MethodImplOptions.AggressiveInlining)]
766 protected virtual TLink Decrement(TLink link) => Arithmetic<TLink>.Decrement(link);
767
768 #region Disposable
769
770 protected override bool AllowMultipleDisposeCalls
771 {
772     [MethodImpl(MethodImplOptions.AggressiveInlining)]
773     get => true;
774 }
775
776 [MethodImpl(MethodImplOptions.AggressiveInlining)]
777 protected override void Dispose(bool manual, bool wasDisposed)
778 {
779     if (!wasDisposed)
780     {
781         ResetPointers();
782         _dataMemory.DisposeIfPossible();
783         _indexMemory.DisposeIfPossible();
784     }
785 }
786
787 #endregion
788 }
789 }

```

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     {
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 RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) => ref
32             ↳ AsRef<RawLinkDataPart<TLink>>(_links + (RawLinkDataPart<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) =>
43             ↳ GetLinkDataPartReference(element).Source;
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

40     protected override TLink GetNext(TLink element) =>
41         ↪ GetLinkDataPartReference(element).Target;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override TLink GetSize() => GetHeaderReference().FreeLinks;
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override void SetFirst(TLink element) => GetHeaderReference().FirstFreeLink =
48         ↪ element;
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override void SetLast(TLink element) => GetHeaderReference().LastFreeLink =
52         ↪ element;
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override void SetPrevious(TLink element, TLink previous) =>
56         ↪ GetLinkDataPartReference(element).Source = previous;
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     protected override void SetNext(TLink element, TLink next) =>
60         ↪ GetLinkDataPartReference(element).Target = next;
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     protected override void SetSize(TLink size) => GetHeaderReference().FreeLinks = size;
64 }

```

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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public override bool Equals(object obj) => obj is RawLinkDataPart<TLink> link ?
22             ↪ Equals(link) : false;
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public bool Equals(RawLinkDataPart<TLink> other)
26             => _equalityComparer.Equals(Source, other.Source)
27             && _equalityComparer.Equals(Target, other.Target);
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public override int GetHashCode() => (Source, Target).GetHashCode();
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public static bool operator ==(RawLinkDataPart<TLink> left, RawLinkDataPart<TLink>
34             ↪ right) => left.Equals(right);
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public static bool operator !=(RawLinkDataPart<TLink> left, RawLinkDataPart<TLink>
38             ↪ right) => !(left == right);
39     }
40 }

```

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 =
13         ↳ EqualityComparer<TLink>.Default;
14
15     public static readonly long SizeInBytes = Structure<RawLinkIndexPart<TLink>>.Size;
16
17     public TLink RootAsSource;
18     public TLink LeftAsSource;
19     public TLink RightAsSource;
20     public TLink SizeAsSource;
21     public TLink RootAsTarget;
22     public TLink LeftAsTarget;
23     public TLink RightAsTarget;
24     public TLink SizeAsTarget;
25
26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     public override bool Equals(object obj) => obj is RawLinkIndexPart<TLink> link ?
28         ↳ Equals(link) : false;
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     public bool Equals(RawLinkIndexPart<TLink> other)
32     => _equalityComparer.Equals(RootAsSource, other.RootAsSource)
33     && _equalityComparer.Equals(LeftAsSource, other.LeftAsSource)
34     && _equalityComparer.Equals(RightAsSource, other.RightAsSource)
35     && _equalityComparer.Equals(SizeAsSource, other.SizeAsSource)
36     && _equalityComparer.Equals(RootAsTarget, other.RootAsTarget)
37     && _equalityComparer.Equals(LeftAsTarget, other.LeftAsTarget)
38     && _equalityComparer.Equals(RightAsTarget, other.RightAsTarget)
39     && _equalityComparer.Equals(SizeAsTarget, other.SizeAsTarget);
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     public override int GetHashCode() => (RootAsSource, LeftAsSource, RightAsSource,
43         ↳ SizeAsSource, RootAsTarget, LeftAsTarget, RightAsTarget, SizeAsTarget).GetHashCode();
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     public static bool operator ==(RawLinkIndexPart<TLink> left, RawLinkIndexPart<TLink>
47         ↳ right) => left.Equals(right);
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     public static bool operator !=(RawLinkIndexPart<TLink> left, RawLinkIndexPart<TLink>
51         ↳ right) => !(left == right);
52 }
53 }

```

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 }

```

```

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

```

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
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override TLink GetZero() => 0U;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override bool EqualToZero(TLink value) => value == 0U;
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     protected override bool AreEqual(TLink first, TLink second) => first == second;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override bool GreaterThanZero(TLink value) => value > 0U;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override bool GreaterThan(TLink first, TLink second) => first > second;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override bool GreaterOrEqualThanZero(TLink value) => true; // value >= 0 is
    ↳ always true for ulong
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool LessOrEqualThanZero(TLink value) => value == 0UL; // value is
    ↳ always >= 0 for ulong
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override bool LessThanZero(TLink value) => false; // value < 0 is always false
    ↳ for ulong
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override bool LessThan(TLink first, TLink second) => first < second;
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override TLink Increment(TLink value) => ++value;
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override TLink Decrement(TLink value) => --value;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override TLink Add(TLink first, TLink second) => first + second;
65
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     protected override TLink Subtract(TLink first, TLink second) => first - second;
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override ref 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/UInt32ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods

```

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 :
9          ↪ UInt32ExternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public
13             ↪ UInt32ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(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() => Header->RootAsSource;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
55             ↪ TLink secondSource, TLink secondTarget)
56             => firstSource < secondSource || firstSource == secondSource && firstTarget <
57             ↪ secondTarget;
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```



```

48     protected override bool FirstIsToTheRightOfSecond(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 void ClearNode(TLink node)
55     {
56         ref var link = ref LinksIndexParts[node];
57         link.LeftAsSource = Zero;
58         link.RightAsSource = Zero;
59         link.SizeAsSource = Zero;
60     }
61 }

```

1.52 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksSourcesSizeBalancedTreeMethods

```

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

```

```

50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override void ClearNode(TLink node)
53     {
54         ref var link = ref LinksIndexParts[node];
55         link.LeftAsSource = Zero;
56         link.RightAsSource = Zero;
57         link.SizeAsSource = Zero;
58     }
59 }
60 }

```

1.53 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods

```

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         [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() => Header->RootAsTarget;
49
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override bool FirstIsToTheLeftOfSecond(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 bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
61         ↳ TLink secondSource, TLink secondTarget)
62         ↳ => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
63         ↳ secondSource;
64
65         [MethodImpl(MethodImplOptions.AggressiveInlining)]
66         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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override void SetSize(TLink node, TLink size) =>
44             ↳ LinksIndexParts[node].SizeAsTarget = size;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         protected override TLink GetTreeRoot() => Header->RootAsTarget;
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]
53         protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
54             ↳ TLink secondSource, TLink secondTarget)
55             => firstTarget < secondTarget || firstTarget == secondTarget && firstSource <
56             ↳ secondSource;
57
58         [MethodImpl(MethodImplOptions.AggressiveInlining)]
59         protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
60             ↳ TLink secondSource, TLink secondTarget)
61             => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
62             ↳ secondSource;
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         protected override void ClearNode(TLink node)
66         {
67             ref var link = ref LinksIndexParts[node];
68             link.LeftAsTarget = Zero;
69             link.RightAsTarget = Zero;
70         }
71     }
72 }

```

```

57         link.SizeAsTarget = Zero;
58     }
59 }
60 }

```

1.55 ./csharp/Platform.Data.Doublets.Memory.Split.Specific/UInt32InternalLinksRecursionlessSizeBalancedTree

```

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)]
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 bool LessThanZero(TLink value) => false; // value < 0 is always false
59         ↳ for ulong
60
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         protected override bool LessThan(TLink first, TLink second) => first < second;
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         protected override TLink Increment(TLink value) => ++value;
66
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         protected override TLink Decrement(TLink value) => --value;
69
70         [MethodImpl(MethodImplOptions.AggressiveInlining)]
71         protected override TLink Add(TLink first, TLink second) => first + second;
72
73         [MethodImpl(MethodImplOptions.AggressiveInlining)]
74         protected override TLink Subtract(TLink first, TLink second) => first - second;

```

```

68     [MethodImpl(MethodImplOptions.AggressiveInlining)]
69     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
70         ↪ ref LinksDataParts[link];
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
74         ↪ ref LinksIndexParts[link];
75
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second) =>
78         ↪ GetKeyPartValue(first) < GetKeyPartValue(second);
79
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second) =>
82         ↪ GetKeyPartValue(first) > GetKeyPartValue(second);
83 }

```

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 :
10         ↪ InternalLinksSizeBalancedTreeMethodsBase<TLink>
11     {
12         protected new readonly RawLinkDataPart<TLink>* LinksDataParts;
13         protected new readonly RawLinkIndexPart<TLink>* LinksIndexParts;
14         protected new readonly LinksHeader<TLink>* Header;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected UInt32InternalLinksSizeBalancedTreeMethodsBase(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 TLink GetZero() => 0U;
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         protected override bool EqualToZero(TLink value) => value == 0U;
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         protected override bool AreEqual(TLink first, TLink second) => first == second;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         protected override bool GreaterThanZero(TLink value) => value > 0U;
38
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         protected override bool GreaterThan(TLink first, TLink second) => first > second;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected override bool GreaterOrEqualThanZero(TLink value) => true; // value >= 0 is
47             ↪ always true for ulong
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool LessOrEqualThanZero(TLink value) => value == 0UL; // value is
51             ↪ always >= 0 for ulong
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;
55
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]
57         protected override bool LessThanZero(TLink value) => false; // value < 0 is always false
58             ↪ for ulong
59
60         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

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

```

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)
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 }

```

1.58 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksSourcesRecursionlessSizeBalancedTreeMethods.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.Specific
7  {
8      public unsafe class UInt32InternalLinksSourcesRecursionlessSizeBalancedTreeMethods :
9          ↪ UInt32InternalLinksRecursionlessSizeBalancedTreeMethodsBase
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

11     public
12         ↳ UInt32InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(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 }

```

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

```

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

```

```

16 [MethodImpl(MethodImplOptions.AggressiveInlining)]
17 protected override ref TLink GetRightReference(TLink node) => ref
    ↳ LinksIndexParts[node].RightAsSource;
18
19 [MethodImpl(MethodImplOptions.AggressiveInlining)]
20 protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsSource;
21
22 [MethodImpl(MethodImplOptions.AggressiveInlining)]
23 protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsSource;
24
25 [MethodImpl(MethodImplOptions.AggressiveInlining)]
26 protected override void SetLeft(TLink node, TLink left) =>
    ↳ LinksIndexParts[node].LeftAsSource = left;
27
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 protected override void SetRight(TLink node, TLink right) =>
    ↳ LinksIndexParts[node].RightAsSource = right;
30
31 [MethodImpl(MethodImplOptions.AggressiveInlining)]
32 protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
33
34 [MethodImpl(MethodImplOptions.AggressiveInlining)]
35 protected override void SetSize(TLink node, TLink size) =>
    ↳ LinksIndexParts[node].SizeAsSource = size;
36
37 [MethodImpl(MethodImplOptions.AggressiveInlining)]
38 protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsSource;
39
40 [MethodImpl(MethodImplOptions.AggressiveInlining)]
41 protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
42
43 [MethodImpl(MethodImplOptions.AggressiveInlining)]
44 protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Target;
45
46 [MethodImpl(MethodImplOptions.AggressiveInlining)]
47 protected override void ClearNode(TLink node)
48 {
49     ref var link = ref LinksIndexParts[node];
50     link.LeftAsSource = Zero;
51     link.RightAsSource = Zero;
52     link.SizeAsSource = Zero;
53 }
54
55 public override TLink Search(TLink source, TLink target) =>
    ↳ SearchCore(GetTreeRoot(source), target);
56 }
57 }

```

1.60 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt32InternalLinksTargetsRecursionlessSizeBalance

```

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 void SetSize(TLink node, TLink size) =>
42         ↳ LinksIndexParts[node].SizeAsTarget = size;
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         protected override void ClearNode(TLink node)
46         {
47             ref var link = ref LinksIndexParts[node];
48             link.LeftAsTarget = Zero;
49             link.RightAsTarget = Zero;
50             link.SizeAsTarget = Zero;
51         }
52
53         public override TLink Search(TLink source, TLink target) =>
54             ↳ SearchCore(GetTreeRoot(source), target);
55     }
56 }

```



```

24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override void SetLeft(TLink node, TLink left) =>
26         ↳ LinksIndexParts[node].LeftAsTarget = left;
27
28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override void SetRight(TLink node, TLink right) =>
30         ↳ LinksIndexParts[node].RightAsTarget = right;
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override void SetSize(TLink node, TLink size) =>
37         ↳ LinksIndexParts[node].SizeAsTarget = size;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override TLink GetTreeRoot(TLink node) => LinksIndexParts[node].RootAsTarget;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Source;
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override void ClearNode(TLink node)
50     {
51         ref var link = ref LinksIndexParts[node];
52         link.LeftAsTarget = Zero;
53         link.RightAsTarget = Zero;
54         link.SizeAsTarget = Zero;
55     }
56
57     public override TLink Search(TLink source, TLink target) =>
58         ↳ SearchCore(GetTreeRoot(target), source);
59 }

```

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)]
12          public UInt32InternalLinksTargetsSizeBalancedTreeMethods(LinksConstants<TLink>
13              ↳ constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
14              ↳ linksIndexParts, LinksHeader<TLink>* header) : base(constants, linksDataParts,
15              ↳ linksIndexParts, header) { }
16
17          [MethodImpl(MethodImplOptions.AggressiveInlining)]
18          protected override ref TLink GetLeftReference(TLink node) => ref
19              ↳ LinksIndexParts[node].LeftAsTarget;
20
21          [MethodImpl(MethodImplOptions.AggressiveInlining)]
22          protected override ref TLink GetRightReference(TLink node) => ref
23              ↳ LinksIndexParts[node].RightAsTarget;
24
25          [MethodImpl(MethodImplOptions.AggressiveInlining)]
26          protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
27
28          [MethodImpl(MethodImplOptions.AggressiveInlining)]
29          protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
30
31          [MethodImpl(MethodImplOptions.AggressiveInlining)]
32          protected override void SetLeft(TLink node, TLink left) =>
33              ↳ LinksIndexParts[node].LeftAsTarget = left;
34
35          [MethodImpl(MethodImplOptions.AggressiveInlining)]
36          protected override void SetRight(TLink node, TLink right) =>
37              ↳ LinksIndexParts[node].RightAsTarget = right;
38
39          [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

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(TLink node) => LinksIndexParts[node].RootAsTarget;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override TLink GetKeyPartValue(TLink node) => LinksDataParts[node].Source;
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     protected override void ClearNode(TLink node)
49     {
50         ref var link = ref LinksIndexParts[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 }

```

1.62 ./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
24         ↪ indexMemory) : this(dataMemory, indexMemory, DefaultLinksSizeStep) { }
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public UInt32SplitMemoryLinks(IResizableDirectMemory dataMemory, IResizableDirectMemory
28         ↪ indexMemory, long memoryReservationStep) : this(dataMemory, indexMemory,
29         ↪ memoryReservationStep, Default<LinksConstants<TLink>>.Instance,
30         ↪ IndexTreeType.Default, useLinkedList: true) { }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public UInt32SplitMemoryLinks(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 UInt32SplitMemoryLinks(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                 ↪ UInt32InternalLinksSourcesSizeBalancedTreeMethods(Constants,
48                 ↪ _linksDataParts, _linksIndexParts, _header);

```

```

37         _createExternalSourceTreeMethods = () => new
38         ↪ UInt32ExternalLinksSourcesSizeBalancedTreeMethods(Constants,
39         ↪ _linksDataParts, _linksIndexParts, _header);
40     }
41     else
42     {
43         _createInternalSourceTreeMethods = () => new
44         ↪ UInt32InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
45         ↪ _linksDataParts, _linksIndexParts, _header);
46         _createExternalSourceTreeMethods = () => new
47         ↪ UInt32ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
48         ↪ _linksDataParts, _linksIndexParts, _header);
49         _createInternalTargetTreeMethods = () => new
50         ↪ UInt32InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(Constants,
51         ↪ _linksDataParts, _linksIndexParts, _header);
52         _createExternalTargetTreeMethods = () => new
53         ↪ UInt32ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods(Constants,
54         ↪ _linksDataParts, _linksIndexParts, _header);
55     }
56     Init(dataMemory, indexMemory);
57 }
58
59 [MethodImpl(MethodImplOptions.AggressiveInlining)]
60 protected override void SetPointers(IResizableDirectMemory dataMemory,
61 ↪ IResizableDirectMemory indexMemory)
62 {
63     _linksDataParts = (RawLinkDataPart<TLink>*)dataMemory.Pointer;
64     _linksIndexParts = (RawLinkIndexPart<TLink>*)indexMemory.Pointer;
65     _header = (LinksHeader<TLink>*)indexMemory.Pointer;
66     if (_useLinkedList)
67     {
68         InternalSourcesListMethods = new
69         ↪ UInt32InternalLinksSourcesLinkedListMethods(Constants, _linksDataParts,
70         ↪ _linksIndexParts);
71     }
72     else
73     {
74         InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
75     }
76     ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
77     InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
78     ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
79     UnusedLinksListMethods = new UInt32UnusedLinksListMethods(_linksDataParts, _header);
80 }
81
82 [MethodImpl(MethodImplOptions.AggressiveInlining)]
83 protected override void ResetPointers()
84 {
85     base.ResetPointers();
86     _linksDataParts = null;
87     _linksIndexParts = null;
88     _header = null;
89 }
90
91 [MethodImpl(MethodImplOptions.AggressiveInlining)]
92 protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
93
94 [MethodImpl(MethodImplOptions.AggressiveInlining)]
95 protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink linkIndex)
96 ↪ => ref _linksDataParts[linkIndex];
97
98 [MethodImpl(MethodImplOptions.AggressiveInlining)]
99 protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink
100 ↪ linkIndex) => ref _linksIndexParts[linkIndex];
101
102 [MethodImpl(MethodImplOptions.AggressiveInlining)]
103 protected override bool AreEqual(TLink first, TLink second) => first == second;
104
105 [MethodImpl(MethodImplOptions.AggressiveInlining)]
106 protected override bool LessThan(TLink first, TLink second) => first < second;
107
108 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

protected override bool LessOrEqualThan(TLink first, TLink second) => first <= second;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override bool GreaterThan(TLink first, TLink second) => first > second;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override bool GreaterOrEqualThan(TLink first, TLink second) => first >= second;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override TLink GetZero() => 0U;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override TLink GetOne() => 1U;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override long ConvertToInt64(TLink value) => value;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override TLink ConvertToAddress(long value) => (TLink)value;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override TLink Add(TLink first, TLink second) => first + second;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override TLink Subtract(TLink first, TLink second) => first - second;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override TLink Increment(TLink link) => ++link;

[MethodImpl(MethodImplOptions.AggressiveInlining)]
protected override TLink Decrement(TLink link) => --link;
}
}

```

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             _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 }

```

1.64 ./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     }
15 }

```

```

13     protected new readonly LinksHeader<TLink>* Header;
14
15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     protected
17     ↪ UInt64ExternalLinksRecursionlessSizeBalancedTreeMethodsBase(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)]
40     protected override bool GreaterThan(ulong first, ulong second) => first > second;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
47     ↪ always true for ulong
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
51     ↪ always >= 0 for ulong
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
58     ↪ for ulong
59
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     protected override bool LessThan(ulong first, ulong second) => first < second;
62
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     protected override ulong Increment(ulong value) => ++value;
65
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     protected override ulong Decrement(ulong value) => --value;
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     protected override ulong Add(ulong first, ulong second) => first + second;
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     protected override ulong Subtract(ulong first, ulong second) => first - second;
74
75     [MethodImpl(MethodImplOptions.AggressiveInlining)]
76     protected override ref LinksHeader<TLink> GetHeaderReference() => ref *Header;
77
78     [MethodImpl(MethodImplOptions.AggressiveInlining)]
79     protected override ref RawLinkDataPart<TLink> GetLinkDataPartReference(TLink link) =>
80     ↪ ref LinksDataParts[link];
81
82     [MethodImpl(MethodImplOptions.AggressiveInlining)]
83     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
84     ↪ ref LinksIndexParts[link];
85
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
88     {
89         ref var firstLink = ref LinksDataParts[first];
90         ref var secondLink = ref LinksDataParts[second];
91         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
92         ↪ secondLink.Source, secondLink.Target);
93     }

```

```

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,
92             ↪ secondLink.Source, secondLink.Target);
93     }
94 }

```

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)]
40         protected override bool GreaterThan(ulong first, ulong second) => first > second;
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
47             ↪ always true for ulong
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
51             ↪ always >= 0 for ulong
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
55
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]
57         protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
58             ↪ for ulong
59
60         [MethodImpl(MethodImplOptions.AggressiveInlining)]
61         protected override bool LessThan(ulong first, ulong second) => first < second;
62
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         protected override ulong Increment(ulong value) => ++value;
65
66         [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 FirstIsToTheLeftOfSecond(TLink first, TLink second)
82     {
83         ref var firstLink = ref LinksDataParts[first];
84         ref var secondLink = ref LinksDataParts[second];
85         return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
86             ↪ secondLink.Source, secondLink.Target);
87     }
88
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     protected override bool FirstIsToTheRightOfSecond(TLink first, TLink second)
91     {
92         ref var firstLink = ref LinksDataParts[first];
93         ref var secondLink = ref LinksDataParts[second];
94         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
95             ↪ secondLink.Source, secondLink.Target);
96     }
97 }
98
99 }

```

1.66 ./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)]
12         public
13             ↪ UInt64ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(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 }

```

```

31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsSource;
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override void SetSize(TLink node, TLink size) =>
36         ↳ LinksIndexParts[node].SizeAsSource = size;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override TLink GetTreeRoot() => Header->RootAsSource;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
46         ↳ TLink secondSource, TLink secondTarget)
47         => firstSource < secondSource || firstSource == secondSource && firstTarget <
48         ↳ secondTarget;
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
52         ↳ TLink secondSource, TLink secondTarget)
53         => firstSource > secondSource || firstSource == secondSource && firstTarget >
54         ↳ secondTarget;
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 }

```

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          [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)]

```



```

35     protected override void SetSize(TLink node, TLink size) =>
36         ↳ LinksIndexParts[node].SizeAsSource = size;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override TLink GetTreeRoot() => Header->RootAsSource;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Source;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
46         ↳ TLink secondSource, TLink secondTarget)
47         => firstSource < secondSource || firstSource == secondSource && firstTarget <
48         ↳ secondTarget;
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
52         ↳ TLink secondSource, TLink secondTarget)
53         => firstSource > secondSource || firstSource == secondSource && firstTarget >
54         ↳ secondTarget;
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 }

```

1.68 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64ExternalLinksTargetsRecursionlessSizeBalance

```

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)]
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 }

```

```

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 FirstIsToLeftOfSecond(TLink firstSource, TLink firstTarget,
45         ↪ TLink secondSource, TLink secondTarget)
46         => firstTarget < secondTarget || firstTarget == secondTarget && firstSource <
47         ↪ secondSource;
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
51         ↪ TLink secondSource, TLink secondTarget)
52         => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
53         ↪ secondSource;
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 }

```

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)]
22          protected override ref TLink GetRightReference(TLink node) => ref
23              ↪ LinksIndexParts[node].RightAsTarget;
24
25          [MethodImpl(MethodImplOptions.AggressiveInlining)]
26          protected override TLink GetLeft(TLink node) => LinksIndexParts[node].LeftAsTarget;
27
28          [MethodImpl(MethodImplOptions.AggressiveInlining)]
29          protected override TLink GetRight(TLink node) => LinksIndexParts[node].RightAsTarget;
30
31          [MethodImpl(MethodImplOptions.AggressiveInlining)]
32          protected override void SetLeft(TLink node, TLink left) =>
33              ↪ LinksIndexParts[node].LeftAsTarget = left;
34
35          [MethodImpl(MethodImplOptions.AggressiveInlining)]
36          protected override void SetRight(TLink node, TLink right) =>
37              ↪ LinksIndexParts[node].RightAsTarget = right;
38
39          [MethodImpl(MethodImplOptions.AggressiveInlining)]
40          protected override TLink GetSize(TLink node) => LinksIndexParts[node].SizeAsTarget;
41
42          [MethodImpl(MethodImplOptions.AggressiveInlining)]
43          protected override void SetSize(TLink node, TLink size) =>
44              ↪ LinksIndexParts[node].SizeAsTarget = size;
45
46          [MethodImpl(MethodImplOptions.AggressiveInlining)]
47          protected override TLink GetTreeRoot() => Header->RootAsTarget;
48
49          [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

41     protected override TLink GetBasePartValue(TLink node) => LinksDataParts[node].Target;
42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
45         ↪ TLink secondSource, TLink secondTarget)
46         => firstTarget < secondTarget || firstTarget == secondTarget && firstSource <
47         ↪ secondSource;
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
51         ↪ TLink secondSource, TLink secondTarget)
52         => firstTarget > secondTarget || firstTarget == secondTarget && firstSource >
53         ↪ secondSource;
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 }

```

1.70 ./csharp/Platform.Data.Doublets.Memory.Split.Specific/UInt64InternalLinksRecursionlessSizeBalancedTreeMethodsBase

```

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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override ulong GetZero() => OUL;
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         protected override bool EqualToZero(ulong value) => value == OUL;
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 > OUL;
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 == OUL; // value is
52         ↪ always >= 0 for ulong
53
54         [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 }

```

1.71 ./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 :
    ↪     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 UInt64InternalLinksSizeBalancedTreeMethodsBase(LinksConstants<TLink>
    ↪     constants, RawLinkDataPart<TLink>* linksDataParts, RawLinkIndexPart<TLink>*
    ↪     linksIndexParts, LinksHeader<TLink>* header)
            : base(constants, (byte*)linksDataParts, (byte*)linksIndexParts, (byte*)header)
17         {
18             LinksDataParts = linksDataParts;
19             LinksIndexParts = linksIndexParts;
20             Header = header;
21         }
22
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected override ulong GetZero() => 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     [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 == 0UL; // 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 }
88
89 }

```

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
28
29
30
31
32
33
34
35
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37
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39
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41
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```

```

24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override ref RawLinkIndexPart<TLink> GetLinkIndexPartReference(TLink link) =>
        ↪ ref _linksIndexParts[link];
26 }
27 }

```

1.73 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksSourcesRecursionlessSizeBalancedTreeMethods

```

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         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         public override TLink Search(TLink source, TLink target) =>
66             ↪ SearchCore(GetTreeRoot(source), target);
67     }
68 }

```

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        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 }

```

1.75 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksTargetsRecursionlessSizeBalancedTreeMethods

```

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)]

```

```

11     public
12         ↳ UInt64InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(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 }

```

1.76 ./csharp/Platform.Data.Doublets/Memory/Split/Specific/UInt64InternalLinksTargetsSizeBalancedTreeMetho

```

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
22
23
24
25
26
27
28
29
30
31
32
33
34
35
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97
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100

```



```

16     [MethodImpl(MethodImplOptions.AggressiveInlining)]
17     protected override ref ulong GetRightReference(ulong 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 }

```

1.77 ./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
    ↳ indexMemory) : this(dataMemory, indexMemory, DefaultLinksSizeStep) { }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public UInt64SplitMemoryLinks(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 UInt64SplitMemoryLinks(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 UInt64SplitMemoryLinks(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
            ↳ UInt64InternalLinksSourcesSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
37         _createExternalSourceTreeMethods = () => new
            ↳ UInt64ExternalLinksSourcesSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
38         _createInternalTargetTreeMethods = () => new
            ↳ UInt64InternalLinksTargetsSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
39         _createExternalTargetTreeMethods = () => new
            ↳ UInt64ExternalLinksTargetsSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
40     }
41     else
42     {
43         _createInternalSourceTreeMethods = () => new
            ↳ UInt64InternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
44         _createExternalSourceTreeMethods = () => new
            ↳ UInt64ExternalLinksSourcesRecursionlessSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
45         _createInternalTargetTreeMethods = () => new
            ↳ UInt64InternalLinksTargetsRecursionlessSizeBalancedTreeMethods(Constants,
            ↳ _linksDataParts, _linksIndexParts, _header);
46         _createExternalTargetTreeMethods = () => new
            ↳ UInt64ExternalLinksTargetsRecursionlessSizeBalancedTreeMethods(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
            ↳ UInt64InternalLinksSourcesLinkedListMethods(Constants, _linksDataParts,
            ↳ _linksIndexParts);
60     }
61     else
62     {
63         InternalSourcesTreeMethods = _createInternalSourceTreeMethods();
64     }
65     ExternalSourcesTreeMethods = _createExternalSourceTreeMethods();
66     InternalTargetsTreeMethods = _createInternalTargetTreeMethods();
67     ExternalTargetsTreeMethods = _createExternalTargetTreeMethods();
68     UnusedLinksListMethods = new UInt64UnusedLinksListMethods(_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(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 }
130 }

```

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)]

```

```

26         protected override ref LinksHeader<TLink> GetHeaderReference() => ref *_header;
27     }
28 }

```

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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
51             ↳ rootSource, TLink rootTarget);
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
55             ↳ rootSource, TLink rootTarget);
56
57         [MethodImpl(MethodImplOptions.AggressiveInlining)]
58         protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
59             ↳ AsRef<LinksHeader<TLink>>(Header);
60
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         protected virtual ref RawLink<TLink> GetLinkReference(TLink link) => ref
63             ↳ AsRef<RawLink<TLink>>(Links + (RawLink<TLink>.SizeInBytes *
64                 ↳ _addressToInt64Converter.Convert(link)));
65
66         [MethodImpl(MethodImplOptions.AggressiveInlining)]
67         protected virtual IList<TLink> GetLinkValues(TLink linkIndex)
68         {
69             ref var link = ref GetLinkReference(linkIndex);
70             return new Link<TLink>(linkIndex, link.Source, link.Target);
71         }
72
73         [MethodImpl(MethodImplOptions.AggressiveInlining)]
74         protected override bool FirstIsToTheLeftOfSecond(TLink first, TLink second)
75         {

```

```

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,
    ↪ _boolToAddressConverter.Convert(value), 3, 1);
121         storedValue = modified;
122     }
123 }
124
125 [MethodImpl(MethodImplOptions.AggressiveInlining)]
126 protected bool IsChild(TLink parent, TLink possibleChild)
127 {
128     var parentSize = GetSize(parent);
129     var childSize = GetSizeOrZero(possibleChild);
130     return GreaterThanZero(childSize) && LessOrEqualThan(childSize, parentSize);
131 }
132
133 [MethodImpl(MethodImplOptions.AggressiveInlining)]
134 protected virtual sbyte GetBalanceValue(TLink storedValue)
135 {
136     unchecked

```

```

137     {
138         var value = _addressToInt32Converter.Convert(Bit<TLink>.PartialRead(storedValue,
139             ↪ 0, 3));
140         value |= 0xF8 * ((value & 4) >> 2); // if negative, then continue ones to the
141             ↪ end of sbyte
142         return (sbyte)value;
143     }
144 }
145 [MethodImpl(MethodImplOptions.AggressiveInlining)]
146 protected virtual void SetBalanceValue(ref TLink storedValue, sbyte value)
147 {
148     unchecked
149     {
150         var packagedValue = _int32ToAddressConverter.Convert((byte)value >> 5 & 4 |
151             ↪ value & 3);
152         var modified = Bit<TLink>.PartialWrite(storedValue, packagedValue, 0, 3);
153         storedValue = modified;
154     }
155 }
156 public TLink this[TLink index]
157 {
158     [MethodImpl(MethodImplOptions.AggressiveInlining)]
159     get
160     {
161         var root = GetTreeRoot();
162         if (GreaterOrEqualThan(index, GetSize(root)))
163         {
164             return Zero;
165         }
166         while (!EqualToZero(root))
167         {
168             var left = GetLeftOrDefault(root);
169             var leftSize = GetSizeOrZero(left);
170             if (LessThan(index, leftSize))
171             {
172                 root = left;
173                 continue;
174             }
175             if (AreEqual(index, leftSize))
176             {
177                 return root;
178             }
179             root = GetRightOrDefault(root);
180             index = Subtract(index, Increment(leftSize));
181         }
182         return Zero; // TODO: Impossible situation exception (only if tree structure
183             ↪ broken)
184     }
185 }
186 /// <summary>
187 /// Выполняет поиск и возвращает индекс связи с указанными Source (началом) и Target
188 /// ↪ (концом).
189 /// </summary>
190 /// <param name="source">Индекс связи, которая является началом на искомой связи.</param>
191 /// <param name="target">Индекс связи, которая является концом на искомой связи.</param>
192 /// <returns>Индекс искомой связи.</returns>
193 [MethodImpl(MethodImplOptions.AggressiveInlining)]
194 public TLink Search(TLink source, TLink target)
195 {
196     var root = GetTreeRoot();
197     while (!EqualToZero(root))
198     {
199         ref var rootLink = ref GetLinkReference(root);
200         var rootSource = rootLink.Source;
201         var rootTarget = rootLink.Target;
202         if (FirstIsToTheLeftOfSecond(source, target, rootSource, rootTarget)) //
203             ↪ node.Key < root.Key
204         {
205             root = GetLeftOrDefault(root);
206         }
207         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
208             ↪ node.Key > root.Key
209         {
210             root = GetRightOrDefault(root);
211         }
212     }
213 }

```

```

208         else // node.Key == root.Key
209         {
210             return root;
211         }
212     }
213     return Zero;
214 }
215
216 // TODO: Return indices range instead of references count
217 [MethodImpl(MethodImplOptions.AggressiveInlining)]
218 public TLink CountUsages(TLink link)
219 {
220     var root = GetTreeRoot();
221     var total = GetSize(root);
222     var totalRightIgnore = Zero;
223     while (!EqualToZero(root))
224     {
225         var @base = GetBasePartValue(root);
226         if (LessOrEqualThan(@base, link))
227         {
228             root = GetRightOrDefault(root);
229         }
230         else
231         {
232             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
233             root = GetLeftOrDefault(root);
234         }
235     }
236     root = GetTreeRoot();
237     var totalLeftIgnore = Zero;
238     while (!EqualToZero(root))
239     {
240         var @base = GetBasePartValue(root);
241         if (GreaterOrEqualThan(@base, link))
242         {
243             root = GetLeftOrDefault(root);
244         }
245         else
246         {
247             totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
248             root = GetRightOrDefault(root);
249         }
250     }
251     return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
252 }
253
254 [MethodImpl(MethodImplOptions.AggressiveInlining)]
255 public TLink EachUsage(TLink link, Func<IList<TLink>, TLink> handler)
256 {
257     var root = GetTreeRoot();
258     if (EqualToZero(root))
259     {
260         return Continue;
261     }
262     TLink first = Zero, current = root;
263     while (!EqualToZero(current))
264     {
265         var @base = GetBasePartValue(current);
266         if (GreaterOrEqualThan(@base, link))
267         {
268             if (AreEqual(@base, link))
269             {
270                 first = current;
271             }
272             current = GetLeftOrDefault(current);
273         }
274         else
275         {
276             current = GetRightOrDefault(current);
277         }
278     }
279     if (!EqualToZero(first))
280     {
281         current = first;
282         while (true)
283         {
284             if (AreEqual(handler(GetLinkValues(current)), Break))
285             {
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)
27         {
28             Links = links;
29             Header = header;
30             Break = constants.Break;
31             Continue = constants.Continue;
32         }
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected abstract TLink GetTreeRoot();
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected abstract TLink GetBasePartValue(TLink link);
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
42             ↳ rootSource, TLink rootTarget);
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         protected abstract bool FirstIsToTheLeftOfSecond(TLink source, TLink target, TLink
46             ↳ rootSource, TLink rootTarget);
47
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         protected virtual ref LinksHeader<TLink> GetHeaderReference() => ref
50             ↳ AsRef<LinksHeader<TLink>>(Header);
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```



```

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

```

```

118     {
119         root = GetLeftOrDefault(root);
120     }
121     else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
122         ↪ node.Key > root.Key
123     {
124         root = GetRightOrDefault(root);
125     }
126     else // node.Key == root.Key
127     {
128         return root;
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
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     {

```

```

194         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
195         {
196             return @break;
197         }
198     }
199     else //if (linkBasePart == @base)
200     {
201         if (AreEqual(handler(GetLinkValues(link)), @break))
202         {
203             return @break;
204         }
205         if (AreEqual(EachUsageCore(@base, GetLeftOrDefault(link), handler), @break))
206         {
207             return @break;
208         }
209         if (AreEqual(EachUsageCore(@base, GetRightOrDefault(link), handler), @break))
210         {
211             return @break;
212         }
213     }
214     return @continue;
215 }
216
217 [MethodImpl(MethodImplOptions.AggressiveInlining)]
218 protected override void PrintNodeValue(TLink node, StringBuilder sb)
219 {
220     ref var link = ref GetLinkReference(node);
221     sb.Append(' ');
222     sb.Append(link.Source);
223     sb.Append('-');
224     sb.Append('>');
225     sb.Append(link.Target);
226 }
227 }
228 }

```

1.81 ./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         protected readonly TLink Break;
20         protected readonly TLink Continue;
21         protected readonly byte* Links;
22         protected readonly byte* Header;
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected LinksSizeBalancedTreeMethodsBase(LinksConstants<TLink> constants, byte* links,
26         ↪ byte* header)
27         {
28             Links = links;
29             Header = header;
30             Break = constants.Break;
31             Continue = constants.Continue;
32         }
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         protected abstract TLink GetTreeRoot();
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         protected abstract TLink GetBasePartValue(TLink link);
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         protected abstract bool FirstIsToTheRightOfSecond(TLink source, TLink target, TLink
42         ↪ rootSource, TLink rootTarget);
43     }
44 }

```

```

40 [MethodImpl(MethodImplOptions.AggressiveInlining)]
41 protected abstract bool FirstIsToLeftOfSecond(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 FirstIsToLeftOfSecond(TLink first, TLink second)
58 {
59     ref var firstLink = ref GetLinkReference(first);
60     ref var secondLink = ref GetLinkReference(second);
61     return FirstIsToLeftOfSecond(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)) //
118             ↪ node.Key < root.Key
119         {
120             root = GetLeftOrDefault(root);
121         }
122         else if (FirstIsToTheRightOfSecond(source, target, rootSource, rootTarget)) //
123             ↪ node.Key > root.Key
124         {
125             root = GetRightOrDefault(root);
126         }
127         else // node.Key == root.Key
128         {
129             return root;
130         }
131     }
132     return Zero;
133 }
134
135 // TODO: Return indices range instead of references count
136 [MethodImpl(MethodImplOptions.AggressiveInlining)]
137 public TLink CountUsages(TLink link)
138 {
139     var root = GetTreeRoot();
140     var total = GetSize(root);
141     var totalRightIgnore = Zero;
142     while (!EqualToZero(root))
143     {
144         var @base = GetBasePartValue(root);
145         if (LessOrEqualThan(@base, link))
146         {
147             root = GetRightOrDefault(root);
148         }
149         else
150         {
151             totalRightIgnore = Add(totalRightIgnore, Increment(GetRightSize(root)));
152             root = GetLeftOrDefault(root);
153         }
154     }
155     root = GetTreeRoot();
156     var totalLeftIgnore = Zero;
157     while (!EqualToZero(root))
158     {
159         var @base = GetBasePartValue(root);
160         if (GreaterOrEqualThan(@base, link))
161         {
162             root = GetLeftOrDefault(root);
163         }
164         else
165         {
166             totalLeftIgnore = Add(totalLeftIgnore, Increment(GetLeftSize(root)));
167             root = GetRightOrDefault(root);
168         }
169     }
170     return Subtract(Subtract(total, totalRightIgnore), totalLeftIgnore);
171 }
172
173 [MethodImpl(MethodImplOptions.AggressiveInlining)]
174 public TLink EachUsage(TLink @base, Func<IList<TLink>, TLink> handler) =>
175     ↪ EachUsageCore(@base, GetTreeRoot(), handler);
176
177 // TODO: 1. Move target, handler to separate object. 2. Use stack or walker 3. Use
178     ↪ low-level MSIL stack.
179 [MethodImpl(MethodImplOptions.AggressiveInlining)]
180 private TLink EachUsageCore(TLink @base, TLink link, Func<IList<TLink>, TLink> handler)
181 {
182     var @continue = Continue;
183     if (EqualToZero(link))
184     {
185         return @continue;
186     }
187     var linkBasePart = GetBasePartValue(link);
188     var @break = Break;

```

```

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

```

1.82 ./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> :
8     ↪ LinksAvlBalancedTreeMethodsBase<TLink>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksSourcesAvlBalancedTreeMethods(LinksConstants<TLink> constants, byte* links,
12         ↪ byte* header) : base(constants, links, header) { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref TLink GetLeftReference(TLink node) => ref
16         ↪ GetLinkReference(node).LeftAsSource;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override ref TLink GetRightReference(TLink node) => ref
20         ↪ GetLinkReference(node).RightAsSource;
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsSource;
24
25         [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

```

```

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

```

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 }

```

```

14 [MethodImpl(MethodImplOptions.AggressiveInlining)]
15 protected override ref TLink GetRightReference(TLink node) => ref
16     ↳ 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) =>
26     ↳ GetLinkReference(node).LeftAsSource = left;
27
28 [MethodImpl(MethodImplOptions.AggressiveInlining)]
29 protected override void SetRight(TLink node, TLink right) =>
30     ↳ GetLinkReference(node).RightAsSource = right;
31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsSource;
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 protected override void SetSize(TLink node, TLink size) =>
37     ↳ GetLinkReference(node).SizeAsSource = size;
38
39 [MethodImpl(MethodImplOptions.AggressiveInlining)]
40 protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Source;
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
47     ↳ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
48     ↳ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
49
50 [MethodImpl(MethodImplOptions.AggressiveInlining)]
51 protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
52     ↳ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
53     ↳ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
54
55 [MethodImpl(MethodImplOptions.AggressiveInlining)]
56 protected override void ClearNode(TLink node)
57 {
58     ref var link = ref GetLinkReference(node);
59     link.LeftAsSource = Zero;
60     link.RightAsSource = Zero;
61     link.SizeAsSource = Zero;
62 }
63 }
64 }

```

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)]

```



```

22     protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsSource;
23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override void SetLeft(TLink node, TLink left) =>
26         ↪ GetLinkReference(node).LeftAsSource = left;
27
28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override void SetRight(TLink node, TLink right) =>
30         ↪ GetLinkReference(node).RightAsSource = right;
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsSource;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override void SetSize(TLink node, TLink size) =>
37         ↪ GetLinkReference(node).SizeAsSource = size;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override TLink GetTreeRoot() => GetHeaderReference().RootAsSource;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Source;
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
47         ↪ TLink secondSource, TLink secondTarget) => LessThan(firstSource, secondSource) ||
48         ↪ (AreEqual(firstSource, secondSource) && LessThan(firstTarget, secondTarget));
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
52         ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstSource, secondSource) ||
53         ↪ (AreEqual(firstSource, secondSource) && GreaterThan(firstTarget, secondTarget));
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     protected override void ClearNode(TLink node)
57     {
58         ref var link = ref GetLinkReference(node);
59         link.LeftAsSource = Zero;
60         link.RightAsSource = Zero;
61         link.SizeAsSource = Zero;
62     }
63 }

```

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>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public LinksTargetsAvlBalancedTreeMethods(LinksConstants<TLink> constants, byte* links,
12             ↪ byte* header) : base(constants, links, header) { }
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref TLink GetLeftReference(TLink node) => ref
16             ↪ GetLinkReference(node).LeftAsTarget;
17
18         [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 }

```

```

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

```

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     }
19 }

```

```

15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     protected override ref TLink GetRightReference(TLink node) => ref
    ↪ GetLinkReference(node).RightAsTarget;
17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsTarget;
20
21     [MethodImpl(MethodImplOptions.AggressiveInlining)]
22     protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsTarget;
23
24     [MethodImpl(MethodImplOptions.AggressiveInlining)]
25     protected override void SetLeft(TLink node, TLink left) =>
    ↪ GetLinkReference(node).LeftAsTarget = left;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override void SetRight(TLink node, TLink right) =>
    ↪ GetLinkReference(node).RightAsTarget = right;
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsTarget;
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     protected override void SetSize(TLink node, TLink size) =>
    ↪ GetLinkReference(node).SizeAsTarget = size;
35
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     protected override TLink GetTreeRoot() => GetHeaderReference().RootAsTarget;
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Target;
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
    ↪ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
    ↪ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
    ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
    ↪ (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));
47
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     protected override void ClearNode(TLink node)
50     {
51         ref var link = ref GetLinkReference(node);
52         link.LeftAsTarget = Zero;
53         link.RightAsTarget = Zero;
54         link.SizeAsTarget = Zero;
55     }
56 }
57 }

```

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> :
    ↪ LinksSizeBalancedTreeMethodsBase<TLink>
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public LinksTargetsSizeBalancedTreeMethods(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).LeftAsTarget;
14
15        [MethodImpl(MethodImplOptions.AggressiveInlining)]
16        protected override ref TLink GetRightReference(TLink node) => ref
    ↪ GetLinkReference(node).RightAsTarget;
17
18        [MethodImpl(MethodImplOptions.AggressiveInlining)]
19        protected override TLink GetLeft(TLink node) => GetLinkReference(node).LeftAsTarget;
20
21        [MethodImpl(MethodImplOptions.AggressiveInlining)]
22        protected override TLink GetRight(TLink node) => GetLinkReference(node).RightAsTarget;

```

```

23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     protected override void SetLeft(TLink node, TLink left) =>
25     ↪ GetLinkReference(node).LeftAsTarget = left;
26
27     [MethodImpl(MethodImplOptions.AggressiveInlining)]
28     protected override void SetRight(TLink node, TLink right) =>
29     ↪ GetLinkReference(node).RightAsTarget = right;
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override TLink GetSize(TLink node) => GetLinkReference(node).SizeAsTarget;
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected override void SetSize(TLink node, TLink size) =>
36     ↪ GetLinkReference(node).SizeAsTarget = size;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override TLink GetTreeRoot() => GetHeaderReference().RootAsTarget;
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     protected override TLink GetBasePartValue(TLink link) => GetLinkReference(link).Target;
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     protected override bool FirstIsToTheLeftOfSecond(TLink firstSource, TLink firstTarget,
46     ↪ TLink secondSource, TLink secondTarget) => LessThan(firstTarget, secondTarget) ||
47     ↪ (AreEqual(firstTarget, secondTarget) && LessThan(firstSource, secondSource));
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override bool FirstIsToTheRightOfSecond(TLink firstSource, TLink firstTarget,
51     ↪ TLink secondSource, TLink secondTarget) => GreaterThan(firstTarget, secondTarget) ||
52     ↪ (AreEqual(firstTarget, secondTarget) && GreaterThan(firstSource, secondSource));
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override void ClearNode(TLink node)
56     {
57         ref var link = ref GetLinkReference(node);
58         link.LeftAsTarget = Zero;
59         link.RightAsTarget = Zero;
60         link.SizeAsTarget = Zero;
61     }
62 }

```

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
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public UnitedMemoryLinks(string address, long memoryReservationStep) : this(new
31         ↪ FileMappedResizableDirectMemory(address, memoryReservationStep),
32         ↪ memoryReservationStep) { }
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public UnitedMemoryLinks(IResizableDirectMemory memory) : this(memory,
36         ↪ DefaultLinksSizeStep) { }
37     }
38 }

```

```

31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 public UnitedMemoryLinks(IResizableDirectMemory memory, long memoryReservationStep) :
    ↳ this(memory, memoryReservationStep, Default<LinksConstants<TLink>>.Instance,
    ↳ IndexTreeType.Default) { }
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 public UnitedMemoryLinks(IResizableDirectMemory memory, long memoryReservationStep,
    ↳ LinksConstants<TLink> constants, IndexTreeType indexTreeType) : base(memory,
    ↳ memoryReservationStep, constants)
37 {
38     if (indexTreeType == IndexTreeType.SizedAndThreadedAVLBalancedTree)
39     {
40         _createSourceTreeMethods = () => new
41             ↳ LinksSourcesAvlBalancedTreeMethods<TLink>(Constants, _links, _header);
42         _createTargetTreeMethods = () => new
43             ↳ LinksTargetsAvlBalancedTreeMethods<TLink>(Constants, _links, _header);
44     }
45     else
46     {
47         _createSourceTreeMethods = () => new
48             ↳ LinksSourcesSizeBalancedTreeMethods<TLink>(Constants, _links, _header);
49         _createTargetTreeMethods = () => new
50             ↳ LinksTargetsSizeBalancedTreeMethods<TLink>(Constants, _links, _header);
51     }
52     Init(memory, memoryReservationStep);
53 }
54
55 [MethodImpl(MethodImplOptions.AggressiveInlining)]
56 protected override void SetPointers(IResizableDirectMemory memory)
57 {
58     _links = (byte*)memory.Pointer;
59     _header = _links;
60     SourcesTreeMethods = _createSourceTreeMethods();
61     TargetsTreeMethods = _createTargetTreeMethods();
62     UnusedLinksListMethods = new UnusedLinksListMethods<TLink>(_links, _header);
63 }
64
65 [MethodImpl(MethodImplOptions.AggressiveInlining)]
66 protected override void ResetPointers()
67 {
68     base.ResetPointers();
69     _links = null;
70     _header = null;
71 }
72
73 [MethodImpl(MethodImplOptions.AggressiveInlining)]
74 protected override ref LinksHeader<TLink> GetHeaderReference() => ref
75     ↳ AsRef<LinksHeader<TLink>>(_header);
76
77 [MethodImpl(MethodImplOptions.AggressiveInlining)]
78 protected override ref RawLink<TLink> GetLinkReference(TLink linkIndex) => ref
79     ↳ AsRef<RawLink<TLink>>(_links + (LinkSizeInBytes * ConvertToInt64(linkIndex)));
80 }
81 }

```

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;

```

```

20 private static readonly UncheckedConverter<long, TLink> _int64ToAddressConverter =
    ↳ UncheckedConverter<long, TLink>.Default;
21
22 private static readonly TLink _zero = default;
23 private static readonly TLink _one = Arithmetic.Increment(_zero);
24
25 /// <summary>Возвращает размер одной связи в байтах.</summary>
26 /// <remarks>
27 /// Используется только во вне класса, не рекомендуется использовать внутри.
28 /// Так как во вне не обязательно будет доступен unsafe C#.
29 /// </remarks>
30 public static readonly long LinkSizeInBytes = RawLink<TLink>.SizeInBytes;
31
32 public static readonly long LinkHeaderSizeInBytes = LinksHeader<TLink>.SizeInBytes;
33
34 public static readonly long DefaultLinksSizeStep = LinkSizeInBytes * 1024 * 1024;
35
36 protected readonly IResizableDirectMemory _memory;
37 protected readonly long _memoryReservationStep;
38
39 protected ILinksTreeMethods<TLink> TargetsTreeMethods;
40 protected ILinksTreeMethods<TLink> SourcesTreeMethods;
41 // TODO: Возможно чтобы гарантированно проверять на то, является ли связь удалённой,
    ↳ нужно использовать не список а дерево, так как так можно быстрее проверить на
    ↳ наличие связи внутри
42 protected ILinksListMethods<TLink> UnusedLinksListMethods;
43
44 /// <summary>
45 /// Возвращает общее число связей находящихся в хранилище.
46 /// </summary>
47 protected virtual TLink Total
48 {
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     get
51     {
52         ref var header = ref GetHeaderReference();
53         return Subtract(header.AllocatedLinks, header.FreeLinks);
54     }
55 }
56
57 public virtual LinksConstants<TLink> Constants
58 {
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     get;
61 }
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 protected UnitedMemoryLinksBase(IResizableDirectMemory memory, long
    ↳ memoryReservationStep, LinksConstants<TLink> constants)
65 {
66     _memory = memory;
67     _memoryReservationStep = memoryReservationStep;
68     Constants = constants;
69 }
70
71 [MethodImpl(MethodImplOptions.AggressiveInlining)]
72 protected UnitedMemoryLinksBase(IResizableDirectMemory memory, long
    ↳ 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(IList<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 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),
118             ↪ TargetsTreeMethods.CountUsages(value));
119     }
120     else
121     {
122         if (!Exists(index))
123         {
124             return GetZero();
125         }
126         if (AreEqual(value, any))
127         {
128             return GetOne();
129         }
130         ref var storedLinkValue = ref GetLinkReference(index);
131         if (AreEqual(storedLinkValue.Source, value) ||
132             ↪ AreEqual(storedLinkValue.Target, value))
133         {
134             return GetOne();
135         }
136         return GetZero();
137     }
138 }
139 if (restrictions.Count == 3)
140 {
141     var source = restrictions[constants.SourcePart];
142     var target = restrictions[constants.TargetPart];
143     if (AreEqual(index, any))
144     {
145         if (AreEqual(source, any) && AreEqual(target, any))
146         {
147             return Total;
148         }
149         else if (AreEqual(source, any))
150         {
151             return TargetsTreeMethods.CountUsages(target);
152         }
153         else if (AreEqual(target, any))
154         {
155             return SourcesTreeMethods.CountUsages(source);
156         }
157         else //if(source != Any && target != Any)
158         {
159             // Эквивалент Exists(source, target) => Count(Any, source, target) > 0
160             var link = SourcesTreeMethods.Search(source, target);
161             return AreEqual(link, constants.Null) ? GetZero() : GetOne();
162         }
163     }
164     else
165     {
166         if (!Exists(index))
167         {
168             return GetZero();
169         }
170     }
171 }

```

```

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     var @continue = constants.Continue;
218     var any = constants.Any;
219     var index = restrictions[constants.IndexPart];
220     if (restrictions.Count == 1)
221     {
222         if (AreEqual(index, any))
223         {
224             return Each(handler, Array.Empty<TLink>());
225         }
226         if (!Exists(index))
227         {
228             return @continue;
229         }
230         return handler(GetLinkStruct(index));
231     }
232     if (restrictions.Count == 2)
233     {
234         var value = restrictions[1];
235         if (AreEqual(index, any))
236         {
237             if (AreEqual(value, any))
238             {
239                 return Each(handler, Array.Empty<TLink>());
240             }
241             if (AreEqual(Each(handler, new Link<TLink>(index, value, any)), @break))

```



```

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         {
294             return @continue;
295         }
296         if (AreEqual(source, any) && AreEqual(target, any))
297         {
298             return handler(GetLinkStruct(index));
299         }
300         ref var storedLinkValue = ref GetLinkReference(index);
301         if (!AreEqual(source, any) && !AreEqual(target, any))
302         {
303             if (AreEqual(storedLinkValue.Source, source) &&
304                 AreEqual(storedLinkValue.Target, target))
305             {
306                 return handler(GetLinkStruct(index));
307             }
308             return @continue;
309         }
310         var value = default(TLink);
311         if (AreEqual(source, any))
312         {
313             value = target;
314         }
315         if (AreEqual(target, any))
316         {
317             value = source;
318         }
319         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
    ↳ в другом месте (но не в менеджере памяти, а в логике Links)
331 /// </remarks>
332 [MethodImpl(MethodImplOptions.AggressiveInlining)]
333 public virtual TLink Update(ICollection<TLink> restrictions, ICollection<TLink> substitution)
334 {
335     var constants = Constants;
336     var @null = constants.Null;
337     var linkIndex = restrictions[constants.IndexPart];
338     ref var link = ref GetLinkReference(linkIndex);
339     ref var header = ref GetHeaderReference();
340     ref var firstAsSource = ref header.RootAsSource;
341     ref var firstAsTarget = ref header.RootAsTarget;
342     // Будет корректно работать только в том случае, если пространство выделенной связи
    ↳ предварительно заполнено нулями
343     if (!AreEqual(link.Source, @null))
344     {
345         SourcesTreeMethods.Detach(ref firstAsSource, linkIndex);
346     }
347     if (!AreEqual(link.Target, @null))
348     {
349         TargetsTreeMethods.Detach(ref firstAsTarget, linkIndex);
350     }
351     link.Source = substitution[constants.SourcePart];
352     link.Target = substitution[constants.TargetPart];
353     if (!AreEqual(link.Source, @null))
354     {
355         SourcesTreeMethods.Attach(ref firstAsSource, linkIndex);
356     }
357     if (!AreEqual(link.Target, @null))
358     {
359         TargetsTreeMethods.Attach(ref firstAsTarget, linkIndex);
360     }
361     return linkIndex;
362 }
363
364 /// <remarks>
365 /// TODO: Возможно нужно будет заполнение нулями, если внешнее API ими не заполняет
    ↳ пространство
366 /// </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 /
    ↳ LinkSizeInBytes);
389         }
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
422 [MethodImpl(MethodImplOptions.AggressiveInlining)]
423 public ICollection<TLink> GetLinkStruct(TLink linkIndex)
424 {
425     ref var link = ref GetLinkReference(linkIndex);
426     return new Link<TLink>(linkIndex, link.Source, link.Target);
427 }
428
429 /// <remarks>
430 /// TODO: Возможно это должно быть событием, вызываемым из IMemory, в том случае, если
431 /// ↳ адрес реально поменялся
432 ///
433 /// Указатель this.links может быть в том же месте,
434 /// так как 0-я связь не используется и имеет такой же размер как Header,
435 /// поэтому header размещается в том же месте, что и 0-я связь
436 /// </remarks>
437 [MethodImpl(MethodImplOptions.AggressiveInlining)]
438 protected abstract void SetPointers(IResizableDirectMemory memory);
439
440 [MethodImpl(MethodImplOptions.AggressiveInlining)]
441 protected virtual void ResetPointers()
442 {
443     SourcesTreeMethods = null;
444     TargetsTreeMethods = null;
445     UnusedLinksListMethods = null;
446 }
447
448 [MethodImpl(MethodImplOptions.AggressiveInlining)]
449 protected abstract ref LinkHeader<TLink> GetHeaderReference();
450
451 [MethodImpl(MethodImplOptions.AggressiveInlining)]
452 protected abstract ref RawLink<TLink> GetLinkReference(TLink linkIndex);
453
454 [MethodImpl(MethodImplOptions.AggressiveInlining)]
455 protected virtual bool Exists(TLink link)
456 => GreaterOrEqualThan(link, Constants.InternalReferencesRange.Minimum)
457     && LessOrEqualThan(link, GetHeaderReference().AllocatedLinks)
458     && !IsUnusedLink(link);
459
460 [MethodImpl(MethodImplOptions.AggressiveInlining)]
461 protected virtual bool IsUnusedLink(TLink linkIndex)
462 {
463     if (!AreEqual(GetHeaderReference().FirstFreeLink, linkIndex)) // May be this check
464         ↳ is not needed
465     {
466         ref var link = ref GetLinkReference(linkIndex);
467         return AreEqual(link.SizeAsSource, default) && !AreEqual(link.Source, default);
468     }
469     else
470     {
471         return true;
472     }
473 }

```

```

468     }
469 }
470
471 [MethodImpl(MethodImplOptions.AggressiveInlining)]
472 protected virtual TLink GetOne() => _one;
473
474 [MethodImpl(MethodImplOptions.AggressiveInlining)]
475 protected virtual TLink GetZero() => default;
476
477 [MethodImpl(MethodImplOptions.AggressiveInlining)]
478 protected virtual bool AreEqual(TLink first, TLink second) =>
479     ↳ _equalityComparer.Equals(first, second);
480
481 [MethodImpl(MethodImplOptions.AggressiveInlining)]
482 protected virtual bool LessThan(TLink first, TLink second) => _comparer.Compare(first,
483     ↳ second) < 0;
484
485 [MethodImpl(MethodImplOptions.AggressiveInlining)]
486 protected virtual bool LessOrEqualThan(TLink first, TLink second) =>
487     ↳ _comparer.Compare(first, second) <= 0;
488
489 [MethodImpl(MethodImplOptions.AggressiveInlining)]
490 protected virtual bool GreaterThan(TLink first, TLink second) =>
491     ↳ _comparer.Compare(first, second) > 0;
492
493 [MethodImpl(MethodImplOptions.AggressiveInlining)]
494 protected virtual bool GreaterOrEqualThan(TLink first, TLink second) =>
495     ↳ _comparer.Compare(first, second) >= 0;
496
497 [MethodImpl(MethodImplOptions.AggressiveInlining)]
498 protected virtual long ConvertToInt64(TLink value) =>
499     ↳ _addressToInt64Converter.Convert(value);
500
501 [MethodImpl(MethodImplOptions.AggressiveInlining)]
502 protected virtual TLink ConvertToAddress(long value) =>
503     ↳ _int64ToAddressConverter.Convert(value);
504
505 [MethodImpl(MethodImplOptions.AggressiveInlining)]
506 protected virtual TLink Add(TLink first, TLink second) => Arithmetic<TLink>.Add(first,
507     ↳ second);
508
509 [MethodImpl(MethodImplOptions.AggressiveInlining)]
510 protected virtual TLink Subtract(TLink first, TLink second) =>
511     ↳ Arithmetic<TLink>.Subtract(first, second);
512
513 [MethodImpl(MethodImplOptions.AggressiveInlining)]
514 protected virtual TLink Increment(TLink link) => Arithmetic<TLink>.Increment(link);
515
516 [MethodImpl(MethodImplOptions.AggressiveInlining)]
517 protected virtual TLink Decrement(TLink link) => Arithmetic<TLink>.Decrement(link);
518
519 #region Disposable
520
521 protected override bool AllowMultipleDisposeCalls
522 {
523     [MethodImpl(MethodImplOptions.AggressiveInlining)]
524     get => true;
525 }
526
527 [MethodImpl(MethodImplOptions.AggressiveInlining)]
528 protected override void Dispose(bool manual, bool wasDisposed)
529 {
530     if (!wasDisposed)
531     {
532         ResetPointers();
533         _memory.DisposeIfPossible();
534     }
535 }
536
537 #endregion
538 }
539 }
540 }

```

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)]
59         protected override void SetPrevious(TLink element, TLink previous) =>
60             ↳ GetLinkReference(element).Source = previous;
61
62         [MethodImpl(MethodImplOptions.AggressiveInlining)]
63         protected override void SetNext(TLink element, TLink next) =>
64             ↳ GetLinkReference(element).Target = next;
65
66         [MethodImpl(MethodImplOptions.AggressiveInlining)]
67         protected override void SetSize(TLink size) => GetHeaderReference().FreeLinks = size;
68     }
69 }

```

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 }

```

```

14     public static readonly long SizeInBytes = Structure<RawLink<TLink>>.Size;
15
16     public TLink Source;
17     public TLink Target;
18     public TLink LeftAsSource;
19     public TLink RightAsSource;
20     public TLink SizeAsSource;
21     public TLink LeftAsTarget;
22     public TLink RightAsTarget;
23     public TLink SizeAsTarget;
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     public override bool Equals(object obj) => obj is RawLink<TLink> link ? Equals(link) :
        ↳ false;
27
28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     public bool Equals(RawLink<TLink> other)
30         => _equalityComparer.Equals(Source, other.Source)
31         && _equalityComparer.Equals(Target, other.Target)
32         && _equalityComparer.Equals(LeftAsSource, other.LeftAsSource)
33         && _equalityComparer.Equals(RightAsSource, other.RightAsSource)
34         && _equalityComparer.Equals(SizeAsSource, other.SizeAsSource)
35         && _equalityComparer.Equals(LeftAsTarget, other.LeftAsTarget)
36         && _equalityComparer.Equals(RightAsTarget, other.RightAsTarget)
37         && _equalityComparer.Equals(SizeAsTarget, other.SizeAsTarget);
38
39     [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     public override int GetHashCode() => (Source, Target, LeftAsSource, RightAsSource,
        ↳ SizeAsSource, LeftAsTarget, RightAsTarget, SizeAsTarget).GetHashCode();
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     public static bool operator ==(RawLink<TLink> left, RawLink<TLink> right) =>
        ↳ left.Equals(right);
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     public static bool operator !=(RawLink<TLink> left, RawLink<TLink> right) => !(left ==
        ↳ right);
47 }
48 }

```

1.92 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksRecursionlessSizeBalancedTreeMethod

```

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;
13
14         protected UInt32LinksRecursionlessSizeBalancedTreeMethodsBase(LinksConstants<uint>
15             ↳ constants, 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

```

```

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)]

```

```

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 FirstIsToLeftOfSecond(uint first, uint second)
67     {
68         ref var firstLink = ref Links[first];
69         ref var secondLink = ref Links[second];
70         return FirstIsToLeftOfSecond(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 }

```

1.94 ./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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
59         protected override void ClearNode(uint node)
60         {
61             ref var link = ref Links[node];
62             link.LeftAsSource = 0U;
63             link.RightAsSource = 0U;
64             link.SizeAsSource = 0U;
65         }
66     }
67 }

```

1.95 ./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

```

```

14 [MethodImpl(MethodImplOptions.AggressiveInlining)]
15 protected override ref uint GetRightReference(uint node) => ref
    ↳ Links[node].RightAsSource;
16
17 [MethodImpl(MethodImplOptions.AggressiveInlining)]
18 protected override uint GetLeft(uint node) => Links[node].LeftAsSource;
19
20 [MethodImpl(MethodImplOptions.AggressiveInlining)]
21 protected override uint GetRight(uint node) => Links[node].RightAsSource;
22
23 [MethodImpl(MethodImplOptions.AggressiveInlining)]
24 protected override void SetLeft(uint node, uint left) => Links[node].LeftAsSource = left;
25
26 [MethodImpl(MethodImplOptions.AggressiveInlining)]
27 protected override void SetRight(uint node, uint right) => Links[node].RightAsSource =
    ↳ right;
28
29 [MethodImpl(MethodImplOptions.AggressiveInlining)]
30 protected override uint GetSize(uint node) => Links[node].SizeAsSource;
31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 protected override void SetSize(uint node, uint size) => Links[node].SizeAsSource = size;
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 protected override uint GetTreeRoot() => Header->RootAsSource;
37
38 [MethodImpl(MethodImplOptions.AggressiveInlining)]
39 protected override uint GetBasePartValue(uint link) => Links[link].Source;
40
41 [MethodImpl(MethodImplOptions.AggressiveInlining)]
42 protected override bool FirstIsToTheLeftOfSecond(uint firstSource, uint firstTarget,
    ↳ uint secondSource, uint secondTarget)
    ↳ => firstSource < secondSource || (firstSource == secondSource && firstTarget <
    ↳ secondTarget);
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected override bool FirstIsToTheRightOfSecond(uint firstSource, uint firstTarget,
    ↳ uint secondSource, uint secondTarget)
    ↳ => firstSource > secondSource || (firstSource == secondSource && firstTarget >
    ↳ secondTarget);
48
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 }

```

1.96 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt32LinksTargetsRecursionlessSizeBalancedTree

```

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 :
    ↳ UInt32LinksRecursionlessSizeBalancedTreeMethodsBase
8     {
9         public UInt32LinksTargetsRecursionlessSizeBalancedTreeMethods(LinksConstants<uint>
    ↳ constants, RawLink<uint>* links, LinksHeader<uint>* header) : base(constants, links,
    ↳ header) { }
10
11 [MethodImpl(MethodImplOptions.AggressiveInlining)]
12 protected override ref uint GetLeftReference(uint node) => ref Links[node].LeftAsTarget;
13
14 [MethodImpl(MethodImplOptions.AggressiveInlining)]
15 protected override ref uint GetRightReference(uint node) => ref
    ↳ Links[node].RightAsTarget;
16
17 [MethodImpl(MethodImplOptions.AggressiveInlining)]
18 protected override uint GetLeft(uint node) => Links[node].LeftAsTarget;
19
20 [MethodImpl(MethodImplOptions.AggressiveInlining)]
21 protected override uint GetRight(uint node) => Links[node].RightAsTarget;
22

```

```

23 [MethodImpl(MethodImplOptions.AggressiveInlining)]
24 protected override void SetLeft(uint node, uint left) => Links[node].LeftAsTarget = left;
25
26 [MethodImpl(MethodImplOptions.AggressiveInlining)]
27 protected override void SetRight(uint node, uint right) => Links[node].RightAsTarget =
    ↳ right;
28
29 [MethodImpl(MethodImplOptions.AggressiveInlining)]
30 protected override uint GetSize(uint node) => Links[node].SizeAsTarget;
31
32 [MethodImpl(MethodImplOptions.AggressiveInlining)]
33 protected override void SetSize(uint node, uint size) => Links[node].SizeAsTarget = size;
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 protected override uint GetTreeRoot() => Header->RootAsTarget;
37
38 [MethodImpl(MethodImplOptions.AggressiveInlining)]
39 protected override uint GetBasePartValue(uint link) => Links[link].Target;
40
41 [MethodImpl(MethodImplOptions.AggressiveInlining)]
42 protected override bool FirstIsToLeftOfSecond(uint firstSource, uint firstTarget,
    ↳ uint secondSource, uint secondTarget)
    => firstTarget < secondTarget || (firstTarget == secondTarget && firstSource <
    ↳ secondSource);
43
44 [MethodImpl(MethodImplOptions.AggressiveInlining)]
45 protected override bool FirstIsToTheRightOfSecond(uint firstSource, uint firstTarget,
    ↳ uint secondSource, uint secondTarget)
    => firstTarget > secondTarget || (firstTarget == secondTarget && firstSource >
    ↳ secondSource);
46
47 [MethodImpl(MethodImplOptions.AggressiveInlining)]
48 protected override void ClearNode(uint node)
49 {
50     {
51         ref var link = ref Links[node];
52         link.LeftAsTarget = 0U;
53         link.RightAsTarget = 0U;
54         link.SizeAsTarget = 0U;
55     }
56 }
57 }
58 }

```

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         public UInt32LinksTargetsSizeBalancedTreeMethods(LinksConstants<uint> constants,
11             ↳ RawLink<uint>* links, LinksHeader<uint>* header) : base(constants, links, header) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         protected override ref uint GetLeftReference(uint node) => ref Links[node].LeftAsTarget;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected override ref uint GetRightReference(uint node) => ref
18             ↳ Links[node].RightAsTarget;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override uint GetLeft(uint node) => Links[node].LeftAsTarget;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override uint GetRight(uint node) => Links[node].RightAsTarget;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override void SetLeft(uint node, uint left) => Links[node].LeftAsTarget = left;
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected override void SetRight(uint node, uint right) => Links[node].RightAsTarget =
31             ↳ right;
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         protected override uint GetSize(uint node) => Links[node].SizeAsTarget;
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

33     protected override void SetSize(uint node, uint size) => Links[node].SizeAsTarget = size;
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override uint GetTreeRoot() => Header->RootAsTarget;
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     protected override uint GetBasePartValue(uint link) => Links[link].Target;
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;
21         private readonly Func<ILinksTreeMethods<uint>> _createTargetTreeMethods;
22         private LinksHeader<uint>* _header;
23         private RawLink<uint>* _links;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public UInt32UnitedMemoryLinks(string address) : this(address, DefaultLinksSizeStep) { }
27
28         /// <summary>
29         /// Создаёт экземпляр базы данных Links в файле по указанному адресу, с указанным
30         ↪ минимальным шагом расширения базы данных.
31         /// </summary>
32         /// <param name="address">Полный путь к файлу базы данных.</param>
33         /// <param name="memoryReservationStep">Минимальный шаг расширения базы данных в
34         ↪ байтах.</param>
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         public UInt32UnitedMemoryLinks(string address, long memoryReservationStep) : this(new
37             ↪ FileMappedResizableDirectMemory(address, memoryReservationStep),
38             ↪ memoryReservationStep) { }
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         public UInt32UnitedMemoryLinks(IResizableDirectMemory memory) : this(memory,
42             ↪ DefaultLinksSizeStep) { }
43
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         public UInt32UnitedMemoryLinks(IResizableDirectMemory memory, long
46             ↪ memoryReservationStep) : this(memory, memoryReservationStep,
47             ↪ Default<LinksConstants<uint>>.Instance, IndexTreeType.Default) { }

```

```

38 [MethodImpl(MethodImplOptions.AggressiveInlining)]
39 public UInt32UnitedMemoryLinks(IResizableDirectMemory memory, long
40     ↪ memoryReservationStep, LinksConstants<uint> constants, IndexTreeType indexTreeType)
41     ↪ : base(memory, memoryReservationStep, constants)
42 {
43     if (indexTreeType == IndexTreeType.SizeBalancedTree)
44     {
45         _createSourceTreeMethods = () => new
46             ↪ UInt32LinksSourcesSizeBalancedTreeMethods(Constants, _links, _header);
47         _createTargetTreeMethods = () => new
48             ↪ UInt32LinksTargetsSizeBalancedTreeMethods(Constants, _links, _header);
49     }
50     else
51     {
52         _createSourceTreeMethods = () => new
53             ↪ UInt32LinksSourcesRecursionlessSizeBalancedTreeMethods(Constants, _links,
54             ↪ _header);
55         _createTargetTreeMethods = () => new
56             ↪ UInt32LinksTargetsRecursionlessSizeBalancedTreeMethods(Constants, _links,
57             ↪ _header);
58     }
59     Init(memory, memoryReservationStep);
60 }
61
62 [MethodImpl(MethodImplOptions.AggressiveInlining)]
63 protected override void SetPointers(IResizableDirectMemory memory)
64 {
65     _header = (LinksHeader<uint>*)memory.Pointer;
66     _links = (RawLink<uint>*)memory.Pointer;
67     SourcesTreeMethods = _createSourceTreeMethods();
68     TargetsTreeMethods = _createTargetTreeMethods();
69     UnusedLinksListMethods = new UInt32UnusedLinksListMethods(_links, _header);
70 }
71
72 [MethodImpl(MethodImplOptions.AggressiveInlining)]
73 protected override void ResetPointers()
74 {
75     base.ResetPointers();
76     _links = null;
77     _header = null;
78 }
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 protected override ref LinksHeader<uint> GetHeaderReference() => ref *_header;
82
83 [MethodImpl(MethodImplOptions.AggressiveInlining)]
84 protected override ref RawLink<uint> GetLinkReference(uint linkIndex) => ref
85     ↪ _links[linkIndex];
86
87 [MethodImpl(MethodImplOptions.AggressiveInlining)]
88 protected override bool AreEqual(uint first, uint second) => first == second;
89
90 [MethodImpl(MethodImplOptions.AggressiveInlining)]
91 protected override bool LessThan(uint first, uint second) => first < second;
92
93 [MethodImpl(MethodImplOptions.AggressiveInlining)]
94 protected override bool LessOrEqualThan(uint first, uint second) => first <= second;
95
96 [MethodImpl(MethodImplOptions.AggressiveInlining)]
97 protected override bool GreaterThan(uint first, uint second) => first > second;
98
99 [MethodImpl(MethodImplOptions.AggressiveInlining)]
100 protected override bool GreaterOrEqualThan(uint first, uint second) => first >= second;
101
102 [MethodImpl(MethodImplOptions.AggressiveInlining)]
103 protected override uint GetZero() => 0U;
104
105 [MethodImpl(MethodImplOptions.AggressiveInlining)]
106 protected override uint GetOne() => 1U;
107
108 [MethodImpl(MethodImplOptions.AggressiveInlining)]
109 protected override long ConvertToInt64(uint value) => (long)value;
110
111 [MethodImpl(MethodImplOptions.AggressiveInlining)]
112 protected override uint ConvertToAddress(long value) => (uint)value;
113
114 [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>
11     {
12         protected new readonly RawLink<ulong>* Links;
13         protected new readonly LinksHeader<ulong>* Header;
14
15         protected UInt64LinksAvlBalancedTreeMethodsBase(LinksConstants<ulong> constants,
16             ↳ RawLink<ulong>* links, LinksHeader<ulong>* header)
17             : base(constants, (byte*)links, (byte*)header)
18         {
19             Links = links;
20             Header = header;
21         }
22
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 }

```

```

36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
38
39 [MethodImpl(MethodImplOptions.AggressiveInlining)]
40 protected override bool GreaterOrEqualThanZero(ulong value) => true; // value >= 0 is
    ↳ always true for ulong
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 protected override bool LessOrEqualThanZero(ulong value) => value == 0UL; // value is
    ↳ always >= 0 for ulong
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 protected override bool LessThanZero(ulong value) => false; // value < 0 is always false
    ↳ for ulong
50
51 [MethodImpl(MethodImplOptions.AggressiveInlining)]
52 protected override bool LessThan(ulong first, ulong second) => first < second;
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 protected override ulong Increment(ulong value) => ++value;
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 protected override ulong Decrement(ulong value) => --value;
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 protected override ulong Add(ulong first, ulong second) => first + second;
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 protected override ulong Subtract(ulong first, ulong second) => first - second;
65
66 [MethodImpl(MethodImplOptions.AggressiveInlining)]
67 protected override bool FirstIsToTheLeftOfSecond(ulong first, ulong second)
68 {
69     ref var firstLink = ref Links[first];
70     ref var secondLink = ref Links[second];
71     return FirstIsToTheLeftOfSecond(firstLink.Source, firstLink.Target,
    ↳ secondLink.Source, secondLink.Target);
72 }
73
74 [MethodImpl(MethodImplOptions.AggressiveInlining)]
75 protected override bool FirstIsToTheRightOfSecond(ulong first, ulong second)
76 {
77     ref var firstLink = ref Links[first];
78     ref var secondLink = ref Links[second];
79     return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
    ↳ secondLink.Source, secondLink.Target);
80 }
81
82 [MethodImpl(MethodImplOptions.AggressiveInlining)]
83 protected override ulong GetSizeValue(ulong value) => (value & 4294967264UL) >> 5;
84
85 [MethodImpl(MethodImplOptions.AggressiveInlining)]
86 protected override void SetSizeValue(ref ulong storedValue, ulong size) => storedValue =
    ↳ storedValue & 31UL | (size & 134217727UL) << 5;
87
88 [MethodImpl(MethodImplOptions.AggressiveInlining)]
89 protected override bool GetLeftIsChildValue(ulong value) => (value & 16UL) >> 4 == 1UL;
90
91 [MethodImpl(MethodImplOptions.AggressiveInlining)]
92 protected override void SetLeftIsChildValue(ref ulong storedValue, bool value) =>
    ↳ storedValue = storedValue & 4294967279UL | (As<bool, byte>(ref value) & 1UL) << 4;
93
94 [MethodImpl(MethodImplOptions.AggressiveInlining)]
95 protected override bool GetRightIsChildValue(ulong value) => (value & 8UL) >> 3 == 1UL;
96
97 [MethodImpl(MethodImplOptions.AggressiveInlining)]
98 protected override void SetRightIsChildValue(ref ulong storedValue, bool value) =>
    ↳ storedValue = storedValue & 4294967287UL | (As<bool, byte>(ref value) & 1UL) << 3;
99
100 [MethodImpl(MethodImplOptions.AggressiveInlining)]
101 protected override sbyte GetBalanceValue(ulong value) => unchecked((sbyte)(value & 7UL |
    ↳ 0xF8UL * ((value & 4UL) >> 2))); // if negative, then continue ones to the end of
    ↳ sbyte
102
103 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

104     protected override void SetBalanceValue(ref ulong storedValue, sbyte value) =>
        ↳ storedValue = unchecked(storedValue & 4294967288UL | (ulong)((byte)value >> 5 & 4 |
        ↳ value & 3) & 7UL);
105
106     [MethodImpl(MethodImplOptions.AggressiveInlining)]
107     protected override ref LinksHeader<ulong> GetHeaderReference() => ref *Header;
108
109     [MethodImpl(MethodImplOptions.AggressiveInlining)]
110     protected override ref RawLink<ulong> GetLinkReference(ulong link) => ref Links[link];
111 }
112 }

```

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)]
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)]

```



```

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,
71             ↪ secondLink.Source, secondLink.Target);
72     }
73
74     [MethodImpl(MethodImplOptions.AggressiveInlining)]
75     protected override bool FirstIsToTheRightOfSecond(ulong first, ulong second)
76     {
77         ref var firstLink = ref Links[first];
78         ref var secondLink = ref Links[second];
79         return FirstIsToTheRightOfSecond(firstLink.Source, firstLink.Target,
80             ↪ secondLink.Source, secondLink.Target);
81     }
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override ref LinksHeader<ulong> GetHeaderReference() => ref *Header;
85
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     protected override ref RawLink<ulong> GetLinkReference(ulong link) => ref Links[link];
88 }

```

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 :
9          ↪ LinksSizeBalancedTreeMethodsBase<ulong>
10     {
11         protected new readonly RawLink<ulong>* Links;
12         protected new readonly LinksHeader<ulong>* Header;
13
14         protected UInt64LinksSizeBalancedTreeMethodsBase(LinksConstants<ulong> constants,
15             ↪ RawLink<ulong>* links, LinksHeader<ulong>* header)
16             : base(constants, (byte*)links, (byte*)header)
17         {
18             Links = links;
19             Header = header;
20         }
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected override ulong GetZero() => OUL;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected override bool EqualToZero(ulong value) => value == OUL;
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 > OUL;
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 == OUL; // 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)]

```

```

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 }

```

1.103 ./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 :
    ↪ UInt64LinksAvlBalancedTreeMethodsBase
8      {
9          public UInt64LinksSourcesAvlBalancedTreeMethods(LinksConstants<ulong> constants,
    ↪ RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants, links, header)
    ↪ { }
10
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         protected override ref ulong GetLeftReference(ulong node) => ref
    ↪ Links[node].LeftAsSource;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         protected override ref ulong GetRightReference(ulong node) => ref
    ↪ Links[node].RightAsSource;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected override ulong GetLeft(ulong node) => Links[node].LeftAsSource;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override ulong GetRight(ulong node) => Links[node].RightAsSource;
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsSource =
    ↪ left;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         protected override void SetRight(ulong node, ulong right) => Links[node].RightAsSource =
    ↪ right;

```

```

28     [MethodImpl(MethodImplOptions.AggressiveInlining)]
29     protected override ulong GetSize(ulong node) => GetSizeValue(Links[node].SizeAsSource);
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected override void SetSize(ulong node, ulong size) => SetSizeValue(ref
33         ↳ Links[node].SizeAsSource, size);
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     protected override bool GetLeftIsChild(ulong node) =>
37         ↳ GetLeftIsChildValue(Links[node].SizeAsSource);
38
39     // [MethodImpl(MethodImplOptions.AggressiveInlining)]
40     // protected override bool GetLeftIsChild(ulong node) => IsChild(node, GetLeft(node));
41
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     protected override void SetLeftIsChild(ulong node, bool value) =>
44         ↳ SetLeftIsChildValue(ref Links[node].SizeAsSource, value);
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     protected override bool GetRightIsChild(ulong node) =>
48         ↳ GetRightIsChildValue(Links[node].SizeAsSource);
49
50     // [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     // protected override bool GetRightIsChild(ulong node) => IsChild(node, GetRight(node));
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     protected override void SetRightIsChild(ulong node, bool value) =>
55         ↳ SetRightIsChildValue(ref Links[node].SizeAsSource, value);
56
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     protected override sbyte GetBalance(ulong node) =>
59         ↳ GetBalanceValue(Links[node].SizeAsSource);
60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     protected override void SetBalance(ulong node, sbyte value) => SetBalanceValue(ref
63         ↳ Links[node].SizeAsSource, value);
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     protected override ulong GetTreeRoot() => Header->RootAsSource;
67
68     [MethodImpl(MethodImplOptions.AggressiveInlining)]
69     protected override ulong GetBasePartValue(ulong link) => Links[link].Source;
70
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     protected override bool FirstIsToTheLeftOfSecond(ulong firstSource, ulong firstTarget,
73         ↳ ulong secondSource, ulong secondTarget)
74         => firstSource < secondSource || (firstSource == secondSource && firstTarget <
75         ↳ secondTarget);
76
77     [MethodImpl(MethodImplOptions.AggressiveInlining)]
78     protected override bool FirstIsToTheRightOfSecond(ulong firstSource, ulong firstTarget,
79         ↳ ulong secondSource, ulong secondTarget)
80         => firstSource > secondSource || (firstSource == secondSource && firstTarget >
81         ↳ secondTarget);
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     protected override void ClearNode(ulong node)
85     {
86         ref var link = ref Links[node];
87         link.LeftAsSource = OUL;
88         link.RightAsSource = OUL;
89         link.SizeAsSource = OUL;
90     }
91 }
92

```

1.104 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksSourcesRecursionlessSizeBalancedTreeMethods

```

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

```

```

9      public UInt64LinksSourcesRecursionlessSizeBalancedTreeMethods(LinksConstants<ulong>
    ↪ constants, RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants,
    ↪ links, header) { }

10
11      [MethodImpl(MethodImplOptions.AggressiveInlining)]
12      protected override ref ulong GetLeftReference(ulong node) => ref
    ↪ Links[node].LeftAsSource;

13
14      [MethodImpl(MethodImplOptions.AggressiveInlining)]
15      protected override ref ulong GetRightReference(ulong node) => ref
    ↪ Links[node].RightAsSource;

16
17      [MethodImpl(MethodImplOptions.AggressiveInlining)]
18      protected override ulong GetLeft(ulong node) => Links[node].LeftAsSource;

19
20      [MethodImpl(MethodImplOptions.AggressiveInlining)]
21      protected override ulong GetRight(ulong node) => Links[node].RightAsSource;

22
23      [MethodImpl(MethodImplOptions.AggressiveInlining)]
24      protected override void SetLeft(ulong node, ulong left) => Links[node].LeftAsSource =
    ↪ left;

25
26      [MethodImpl(MethodImplOptions.AggressiveInlining)]
27      protected override void SetRight(ulong node, ulong right) => Links[node].RightAsSource =
    ↪ right;

28
29      [MethodImpl(MethodImplOptions.AggressiveInlining)]
30      protected override ulong GetSize(ulong node) => Links[node].SizeAsSource;

31
32      [MethodImpl(MethodImplOptions.AggressiveInlining)]
33      protected override void SetSize(ulong node, ulong size) => Links[node].SizeAsSource =
    ↪ size;

34
35      [MethodImpl(MethodImplOptions.AggressiveInlining)]
36      protected override ulong GetTreeRoot() => Header->RootAsSource;

37
38      [MethodImpl(MethodImplOptions.AggressiveInlining)]
39      protected override ulong GetBasePartValue(ulong link) => Links[link].Source;

40
41      [MethodImpl(MethodImplOptions.AggressiveInlining)]
42      protected override bool FirstIsToLeftOfSecond(ulong firstSource, ulong firstTarget,
    ↪ ulong secondSource, ulong secondTarget)
43      => firstSource < secondSource || (firstSource == secondSource && firstTarget <
    ↪ secondTarget);

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

48
49      [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 :
    ↪ UInt64LinksSizeBalancedTreeMethodsBase
8          {
9              public UInt64LinksSourcesSizeBalancedTreeMethods(LinksConstants<ulong> constants,
    ↪ RawLink<ulong>* links, LinksHeader<ulong>* header) : base(constants, links, header)
    ↪ { }

10
11              [MethodImpl(MethodImplOptions.AggressiveInlining)]
12              protected override ref ulong GetLeftReference(ulong node) => ref
    ↪ Links[node].LeftAsSource;

```

```

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

```

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         public UInt64LinksTargetsAvlBalancedTreeMethods(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         => 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.LeftAsTarget = OUL;
66             link.RightAsTarget = OUL;
67             link.SizeAsTarget = OUL;
68         }
69     }
70 }

```

```

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

```

1.107 ./csharp/Platform.Data.Doublets/Memory/United/Specific/UInt64LinksTargetsRecursionlessSizeBalancedTr

```

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 >
  ↳ secondSource);

48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override void ClearNode(ulong node)
51     {
52         ref var link = ref Links[node];
53         link.LeftAsTarget = OUL;
54         link.RightAsTarget = OUL;
55         link.SizeAsTarget = OUL;
56     }
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 :
  ↳ UInt64LinksSizeBalancedTreeMethodsBase
8     {
9         public UInt64LinksTargetsSizeBalancedTreeMethods(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 >
    ↳ secondSource);
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     protected override void ClearNode(ulong node)
51     {
52         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
    ↳ organizing the storage of links with addresses represented as <see cref="ulong"
    ↳ />.</para>
13     /// <para>Представляет низкоуровневую реализация прямого доступа к памяти с переменным
    ↳ размером, для организации хранения связей с адресами представленными в виде <see
    ↳ cref="ulong"/>.</para>
14     /// </summary>
15     public unsafe class UInt64UnitedMemoryLinks : UnitedMemoryLinksBase<ulong>
16     {

```



```

17 private readonly Func<ILinksTreeMethods<ulong>> _createSourceTreeMethods;
18 private readonly Func<ILinksTreeMethods<ulong>> _createTargetTreeMethods;
19 private LinksHeader<ulong>* _header;
20 private RawLink<ulong>* _links;
21
22 [MethodImpl(MethodImplOptions.AggressiveInlining)]
23 public UInt64UnitedMemoryLinks(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 UInt64UnitedMemoryLinks(string address, long memoryReservationStep) : this(new
34   ↳ FileMappedResizableDirectMemory(address, memoryReservationStep),
35   ↳ memoryReservationStep) { }
36
37 [MethodImpl(MethodImplOptions.AggressiveInlining)]
38 public UInt64UnitedMemoryLinks(IResizableDirectMemory memory) : this(memory,
39   ↳ DefaultLinksSizeStep) { }
40
41 [MethodImpl(MethodImplOptions.AggressiveInlining)]
42 public UInt64UnitedMemoryLinks(IResizableDirectMemory memory, long
43   ↳ memoryReservationStep) : this(memory, memoryReservationStep,
44   ↳ Default<LinksConstants<ulong>>.Instance, IndexTreeType.Default) { }
45
46 [MethodImpl(MethodImplOptions.AggressiveInlining)]
47 public UInt64UnitedMemoryLinks(IResizableDirectMemory memory, long
48   ↳ memoryReservationStep, LinksConstants<ulong> constants, IndexTreeType indexTreeType)
49   ↳ : base(memory, memoryReservationStep, constants)
50 {
51     if (indexTreeType == IndexTreeType.SizedAndThreadedAVLBalancedTree)
52     {
53         _createSourceTreeMethods = () => new
54           ↳ UInt64LinksSourcesAvlBalancedTreeMethods(Constants, _links, _header);
55         _createTargetTreeMethods = () => new
56           ↳ UInt64LinksTargetsAvlBalancedTreeMethods(Constants, _links, _header);
57     }
58     else if (indexTreeType == IndexTreeType.SizeBalancedTree)
59     {
60         _createSourceTreeMethods = () => new
61           ↳ UInt64LinksSourcesSizeBalancedTreeMethods(Constants, _links, _header);
62         _createTargetTreeMethods = () => new
63           ↳ UInt64LinksTargetsSizeBalancedTreeMethods(Constants, _links, _header);
64     }
65     else
66     {
67         _createSourceTreeMethods = () => new
68           ↳ UInt64LinksSourcesRecursionlessSizeBalancedTreeMethods(Constants, _links,
69           ↳ _header);
70         _createTargetTreeMethods = () => new
71           ↳ UInt64LinksTargetsRecursionlessSizeBalancedTreeMethods(Constants, _links,
72           ↳ _header);
73     }
74     Init(memory, memoryReservationStep);
75 }
76
77 [MethodImpl(MethodImplOptions.AggressiveInlining)]
78 protected override void SetPointers(IResizableDirectMemory memory)
79 {
80     _header = (LinksHeader<ulong>*)memory.Pointer;
81     _links = (RawLink<ulong>*)memory.Pointer;
82     SourcesTreeMethods = _createSourceTreeMethods();
83     TargetsTreeMethods = _createTargetTreeMethods();
84     UnusedLinksListMethods = new UInt64UnusedLinksListMethods(_links, _header);
85 }
86
87 [MethodImpl(MethodImplOptions.AggressiveInlining)]
88 protected override void ResetPointers()
89 {
90     base.ResetPointers();
91     _links = null;
92     _header = null;
93 }

```

```

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
83     ↪     _links[linkIndex];
84
85     [MethodImpl(MethodImplOptions.AggressiveInlining)]
86     protected override bool AreEqual(ulong first, ulong second) => first == second;
87
88     [MethodImpl(MethodImplOptions.AggressiveInlining)]
89     protected override bool LessThan(ulong first, ulong second) => first < second;
90
91     [MethodImpl(MethodImplOptions.AggressiveInlining)]
92     protected override bool LessOrEqualThan(ulong first, ulong second) => first <= second;
93
94     [MethodImpl(MethodImplOptions.AggressiveInlining)]
95     protected override bool GreaterThan(ulong first, ulong second) => first > second;
96
97     [MethodImpl(MethodImplOptions.AggressiveInlining)]
98     protected override bool GreaterOrEqualThan(ulong first, ulong second) => first >= second;
99
100    [MethodImpl(MethodImplOptions.AggressiveInlining)]
101    protected override ulong GetZero() => 0UL;
102
103    [MethodImpl(MethodImplOptions.AggressiveInlining)]
104    protected override ulong GetOne() => 1UL;
105
106    [MethodImpl(MethodImplOptions.AggressiveInlining)]
107    protected override long ConvertToInt64(ulong value) => (long)value;
108
109    [MethodImpl(MethodImplOptions.AggressiveInlining)]
110    protected override ulong ConvertToAddress(long value) => (ulong)value;
111
112    [MethodImpl(MethodImplOptions.AggressiveInlining)]
113    protected override ulong Add(ulong first, ulong second) => first + second;
114
115    [MethodImpl(MethodImplOptions.AggressiveInlining)]
116    protected override ulong Subtract(ulong first, ulong second) => first - second;
117
118    [MethodImpl(MethodImplOptions.AggressiveInlining)]
119    protected override ulong Increment(ulong link) => ++link;
120
121    [MethodImpl(MethodImplOptions.AggressiveInlining)]
122    protected override ulong Decrement(ulong link) => --link;
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/BigIntegerToRawNumberSequenceConverter.cs

```

1  using System;
2  using System.Collections.Generic;

```

```

3 using System.Diagnostics;
4 using System.Numerics;
5 using Platform.Converters;
6 using Platform.Data.Doublets.Decorators;
7 using Platform.Numbers;
8 using Platform.Reflection;
9 using Platform.Unsafe;
10
11
12 namespace Platform.Data.Doublets.Numbers.Raw
13 {
14     public class BigIntegerToRawNumberSequenceConverter<TLink> : LinksDecoratorBase<TLink>,
15         ↪ IConverter<BigInteger, TLink>
16     where TLink : struct
17     {
18         private readonly IConverter<TLink> _addressToNumberConverter;
19         public static readonly int BitsStorableInRawNumber = Structure<TLink>.Size - 1;
20         private static readonly int _bitsPerRawNumber = NumericType<TLink>.BitsSize - 1;
21         private static readonly TLink _maximumValue = NumericType<TLink>.MaxValue;
22         private static readonly TLink _bitMask = Bit.ShiftRight(_maximumValue, 1);
23
24         public BigIntegerToRawNumberSequenceConverter(ILinks<TLink> links, IConverter<TLink>
25             ↪ addressToNumberConverter) : base(links)
26         {
27             _addressToNumberConverter = addressToNumberConverter;
28
29         public TLink Convert(BigInteger bigInt)
30         {
31             var currentBigInt = bigInt;
32             var bigIntBytes = currentBigInt.ToByteArray();
33             var nextBigInt = currentBigInt >> 63;
34             TLink bigIntLink;
35             if (nextBigInt > 0)
36             {
37                 TLink nextBigIntLink = Convert(nextBigInt);
38                 var bigIntWithBitMask = Bit.And(bigIntBytes.ToStructure<TLink>(), _bitMask);
39                 var convertedBigInt = _addressToNumberConverter.Convert(bigIntWithBitMask);
40                 bigIntLink = _links.GetOrCreate(convertedBigInt, nextBigIntLink);
41             }
42             else
43             {
44                 bigIntLink = _addressToNumberConverter.Convert(bigIntBytes.ToStructure<TLink>());
45             }
46             return bigIntLink;
47         }
48     }
49 }

```

1.112 ./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 unchecked<TSource, TTarget> _sourceToTargetConverter =
18             ↪ unchecked<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
33             var address = _numberToAddressConverter.Convert(source);
34             var bigInt = BigInteger.FromBytes(address.ToStructure<TSource>());
35             var bigIntLink = _sourceToTargetConverter.Convert(bigInt);
36             return bigIntLink;
37         }
38     }
39 }

```

```

28         if (externalReferencesRange.HasValue &&
29             ↳ externalReferencesRange.Value.Contains(source))
30         {
31             return
32             ↳ _sourceToTargetConverter.Convert(_numberToAddressConverter.Convert(source));
33         }
34         else
35         {
36             var pair = Links.GetLink(source);
37             var walker = new LeftSequenceWalker<TSource>(Links, new DefaultStack<TSource>(),
38                 ↳ (link) => externalReferencesRange.HasValue &&
39                 ↳ externalReferencesRange.Value.Contains(link));
40             TTarget result = default;
41             foreach (var element in walker.Walk(source))
42             {
43                 result = Bit.Or(Bit.ShiftLeft(result, _bitsPerRawNumber), Convert(element));
44             }
45             return result;
46         }
47     }
48 }

```

1.113 ./csharp/Platform.Data.Doublets/Numbers/Raw/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.Raw
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 }

```

1.114 ./csharp/Platform.Data.Doublets/Numbers/Raw/RawNumberSequenceToBigIntegerConverter.cs

```

1 using System;
2 using System.Numerics;
3 using Platform.Converters;

```

```

4 using Platform.Data.Doublets.Decorators;
5 using Platform.Unsafe;
6
7 namespace Platform.Data.Doublets.Numbers.Raw
8 {
9     public class RawNumberSequenceToBigIntegerConverter<TLink> : LinksDecoratorBase<TLink>,
10        ⇨ IConverter<TLink, BigInteger>
11     where TLink : struct
12     {
13         private readonly IConverter<TLink, TLink> _numberToAddressConverter;
14
15         public RawNumberSequenceToBigIntegerConverter(ILinks<TLink> links, IConverter<TLink,
16        ⇨ TLink> numberToAddressConverter) : base(links)
17         {
18             _numberToAddressConverter = numberToAddressConverter;
19
20         public BigInteger Convert(TLink bigInt)
21         {
22             var convertedBigInt = _numberToAddressConverter.Convert(bigInt);
23             var convertedBigIntBytes = convertedBigInt.ToBytes();
24             return new BigInteger(convertedBigIntBytes);
25         }
26     }
27 }

```

1.115 ./csharp/Platform.Data.Doublets/Numbers/Unary/AddressToUnaryNumberConverter.cs

```

1 using System.Collections.Generic;
2 using Platform.Reflection;
3 using Platform.Converters;
4 using Platform.Numbers;
5 using System.Runtime.CompilerServices;
6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     public class AddressToUnaryNumberConverter<TLink> : LinksOperatorBase<TLink>,
12        ⇨ IConverter<TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15        ⇨ EqualityComparer<TLink>.Default;
16         private static readonly TLink _zero = default;
17         private static readonly TLink _one = Arithmetic.Increment(_zero);
18
19         private readonly IConverter<int, TLink> _powerOf2ToUnaryNumberConverter;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public AddressToUnaryNumberConverter(ILinks<TLink> links, IConverter<int, TLink>
23        ⇨ powerOf2ToUnaryNumberConverter) : base(links) => _powerOf2ToUnaryNumberConverter =
24        ⇨ powerOf2ToUnaryNumberConverter;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public TLink Convert(TLink number)
28         {
29             var links = _links;
30             var nullConstant = links.Constants.Null;
31             var target = nullConstant;
32             for (var i = 0; !_equalityComparer.Equals(number, _zero) && i <
33        ⇨ NumericType<TLink>.BitsSize; i++)
34             {
35                 if (_equalityComparer.Equals(Bit.And(number, _one), _one))
36                 {
37                     target = _equalityComparer.Equals(target, nullConstant)
38                        ? _powerOf2ToUnaryNumberConverter.Convert(i)
39                        : links.GetOrCreate(_powerOf2ToUnaryNumberConverter.Convert(i), target);
40                 }
41                 number = Bit.ShiftRight(number, 1);
42             }
43             return target;
44         }
45     }
46 }

```

1.116 ./csharp/Platform.Data.Doublets/Numbers/Unary/LinkToltsFrequencyNumberConveter.cs

```

1 using System;
2 using System.Collections.Generic;
3 using Platform.Interfaces;
4 using Platform.Converters;
5 using System.Runtime.CompilerServices;

```

```

6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     public class LinkToItsFrequencyNumberConveter<TLink> : LinksOperatorBase<TLink>,
12         ↪ IConverter<Doublet<TLink>, TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15             ↪ EqualityComparer<TLink>.Default;
16
17         private readonly IProperty<TLink, TLink> _frequencyPropertyOperator;
18         private readonly IConverter<TLink> _unaryNumberToAddressConverter;
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public LinkToItsFrequencyNumberConveter(
22             ILinks<TLink> links,
23             IProperty<TLink, TLink> frequencyPropertyOperator,
24             IConverter<TLink> unaryNumberToAddressConverter)
25             : base(links)
26         {
27             _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 }

```

1.117 ./csharp/Platform.Data.Doublets/Numbers/Unary/PowerOf2ToUnaryNumberConverter.cs

```

1 using System.Collections.Generic;
2 using Platform.Exceptions;
3 using Platform.Ranges;
4 using Platform.Converters;
5 using System.Runtime.CompilerServices;
6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     public class PowerOf2ToUnaryNumberConverter<TLink> : LinksOperatorBase<TLink>,
12         ↪ IConverter<int, TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15             ↪ EqualityComparer<TLink>.Default;
16
17         private readonly TLink[] _unaryNumberPowersOf2;
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public PowerOf2ToUnaryNumberConverter(ILinks<TLink> links, TLink one) : base(links)
21         {
22             _unaryNumberPowersOf2 = new TLink[64];
23             _unaryNumberPowersOf2[0] = one;
24         }
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public TLink Convert(int power)
28         {
29             Ensure.Always.ArgumentInRange(power, new Range<int>(0, _unaryNumberPowersOf2.Length
30                 ↪ - 1), nameof(power));
31             if (!_equalityComparer.Equals(_unaryNumberPowersOf2[power], default))
32             {
33                 return _unaryNumberPowersOf2[power];
34             }
35         }
36     }
37 }

```

```

32     var previousPowerOf2 = Convert(power - 1);
33     var powerOf2 = _links.GetOrCreate(previousPowerOf2, previousPowerOf2);
34     _unaryNumberPowersOf2[power] = powerOf2;
35     return powerOf2;
36 }
37 }
38 }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Converters;
4  using Platform.Numbers;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Numbers.Unary
9  {
10     public class UnaryNumberToAddressAddOperationConverter<TLink> : LinksOperatorBase<TLink>,
11         ⇨ IConverter<TLink>
12     {
13         private static readonly EqualityComparer<TLink> _equalityComparer =
14             ⇨ EqualityComparer<TLink>.Default;
15         private static readonly UncheckedConverter<TLink, ulong> _addressToUInt64Converter =
16             ⇨ UncheckedConverter<TLink, ulong>.Default;
17         private static readonly UncheckedConverter<ulong, TLink> _uint64ToAddressConverter =
18             ⇨ UncheckedConverter<ulong, TLink>.Default;
19         private static readonly TLink _zero = default;
20         private static readonly TLink _one = Arithmetic.Increment(_zero);
21
22         private readonly Dictionary<TLink, TLink> _unaryToUInt64;
23         private readonly TLink _unaryOne;
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public UnaryNumberToAddressAddOperationConverter(ILinks<TLink> links, TLink unaryOne)
27             : base(links)
28         {
29             _unaryOne = unaryOne;
30             _unaryToUInt64 = CreateUnaryToUInt64Dictionary(links, unaryOne);
31         }
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         public TLink Convert(TLink unaryNumber)
35         {
36             if (_equalityComparer.Equals(unaryNumber, default))
37             {
38                 return default;
39             }
40             if (_equalityComparer.Equals(unaryNumber, _unaryOne))
41             {
42                 return _one;
43             }
44             var links = _links;
45             var source = links.GetSource(unaryNumber);
46             var target = links.GetTarget(unaryNumber);
47             if (_equalityComparer.Equals(source, target))
48             {
49                 return _unaryToUInt64[unaryNumber];
50             }
51             else
52             {
53                 var result = _unaryToUInt64[source];
54                 TLink lastValue;
55                 while (!_unaryToUInt64.TryGetValue(target, out lastValue))
56                 {
57                     source = links.GetSource(target);
58                     result = Arithmetic<TLink>.Add(result, _unaryToUInt64[source]);
59                     target = links.GetTarget(target);
60                 }
61                 result = Arithmetic<TLink>.Add(result, lastValue);
62                 return result;
63             }
64         }
65
66         [MethodImpl(MethodImplOptions.AggressiveInlining)]
67         private static Dictionary<TLink, TLink> CreateUnaryToUInt64Dictionary(ILinks<TLink>
68             ⇨ links, TLink unaryOne)
69         {
70             var unaryToUInt64 = new Dictionary<TLink, TLink>
71             {

```

```

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) =>
82     ↪ _uint64ToAddressConverter.Convert(_addressToUInt64Converter.Convert(number) * 2UL);
83 }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Reflection;
4  using Platform.Converters;
5  using Platform.Numbers;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     public class UnaryNumberToAddressOrOperationConverter<TLink> : LinksOperatorBase<TLink>,
12         ↪ IConverter<TLink>
13     {
14         private static readonly EqualityComparer<TLink> _equalityComparer =
15             ↪ EqualityComparer<TLink>.Default;
16         private static readonly TLink _zero = default;
17         private static readonly TLink _one = Arithmetic.Increment(_zero);
18
19         private readonly IDictionary<TLink, int> _unaryNumberPowerOf2Indicies;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public UnaryNumberToAddressOrOperationConverter(ILinks<TLink> links, IConverter<int,
23             ↪ TLink> powerOf2ToUnaryNumberConverter) : base(links) => _unaryNumberPowerOf2Indicies
24             ↪ = CreateUnaryNumberPowerOf2IndiciesDictionary(powerOf2ToUnaryNumberConverter);
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public TLink Convert(TLink sourceNumber)
28         {
29             var links = _links;
30             var nullConstant = links.Constants.Null;
31             var source = sourceNumber;
32             var target = nullConstant;
33             if (!_equalityComparer.Equals(source, nullConstant))
34             {
35                 while (true)
36                 {
37                     if (_unaryNumberPowerOf2Indicies.TryGetValue(source, out int powerOf2Index))
38                     {
39                         SetBit(ref target, powerOf2Index);
40                         break;
41                     }
42                     else
43                     {
44                         powerOf2Index = _unaryNumberPowerOf2Indicies[links.GetSource(source)];
45                         SetBit(ref target, powerOf2Index);
46                         source = links.GetTarget(source);
47                     }
48                 }
49             }
50             return target;
51         }
52
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         private static Dictionary<TLink, int>
55             ↪ CreateUnaryNumberPowerOf2IndiciesDictionary(IConverter<int, TLink>
56             ↪ powerOf2ToUnaryNumberConverter)
57         {
58             var unaryNumberPowerOf2Indicies = new Dictionary<TLink, int>();
59             for (int i = 0; i < NumericType<TLink>.BitsSize; i++)
60             {

```



```

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 }

```

1.120 ./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 }

```

1.121 ./csharp/Platform.Data.Doublets/PropertyOperators/PropertyOperator.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.PropertyOperators
8  {
9      public class PropertyOperator<TLink> : LinksOperatorBase<TLink>, IProperty<TLink, TLink>
10     {
11         private static readonly EqualityComparer<TLink> _equalityComparer =
    ↪ EqualityComparer<TLink>.Default;
12
13         private readonly TLink _propertyMarker;
14         private readonly TLink _propertyValueMarker;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public PropertyOperator(ILinks<TLink> links, TLink propertyMarker, TLink
    ↪ propertyValueMarker) : base(links)

```

```

18     {
19         _propertyMarker = propertyMarker;
20         _propertyValueMarker = propertyValueMarker;
21     }
22
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     public TLink Get(TLink link)
25     {
26         var property = _links.SearchOrDefault(link, _propertyMarker);
27         return GetValue(GetContainer(property));
28     }
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     private TLink GetContainer(TLink property)
32     {
33         var valueContainer = default(TLink);
34         if (_equalityComparer.Equals(property, default))
35         {
36             return valueContainer;
37         }
38         var links = _links;
39         var constants = links.Constants;
40         var countinueConstant = constants.Continue;
41         var breakConstant = constants.Break;
42         var anyConstant = constants.Any;
43         var query = new Link<TLink>(anyConstant, property, anyConstant);
44         links.Each(candidate =>
45         {
46             var candidateTarget = links.GetTarget(candidate);
47             var valueTarget = links.GetTarget(candidateTarget);
48             if (_equalityComparer.Equals(valueTarget, _propertyValueMarker))
49             {
50                 valueContainer = links.GetIndex(candidate);
51                 return breakConstant;
52             }
53             return countinueConstant;
54         }, query);
55         return valueContainer;
56     }
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     private TLink GetValue(TLink container) => _equalityComparer.Equals(container, default)
60     ↪ ? default : _links.GetTarget(container);
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     public void Set(TLink link, TLink value)
64     {
65         var links = _links;
66         var property = links.GetOrCreate(link, _propertyMarker);
67         var container = GetContainer(property);
68         if (_equalityComparer.Equals(container, default))
69         {
70             links.GetOrCreate(property, value);
71         }
72         else
73         {
74             links.Update(container, property, value);
75         }
76     }
77 }

```

1.122 ./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(IList<TLink> destination, IList<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 }

```

1.123 ./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;

```

```

33 private LinkFrequency<TLink> _maxDoubletData;
34
35 private struct HalfDoublet
36 {
37     public TLink Element;
38     public LinkFrequency<TLink> DoubletData;
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     public HalfDoublet(TLink element, LinkFrequency<TLink> doubletData)
42     {
43         Element = element;
44         DoubletData = doubletData;
45     }
46
47     public override string ToString() => $"{Element}: ({DoubletData})";
48 }
49
50 [MethodImpl(MethodImplOptions.AggressiveInlining)]
51 public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
    ↳ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache)
    : this(links, baseConverter, doubletFrequenciesCache, _one, true) { }
52
53 [MethodImpl(MethodImplOptions.AggressiveInlining)]
54 public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
    ↳ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, bool
    ↳ doInitialFrequenciesIncrement)
    : this(links, baseConverter, doubletFrequenciesCache, _one,
    ↳ doInitialFrequenciesIncrement) { }
55
56 [MethodImpl(MethodImplOptions.AggressiveInlining)]
57 public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
    ↳ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, TLink
    ↳ minFrequencyToCompress, bool doInitialFrequenciesIncrement)
    : base(links)
58 {
59     _baseConverter = baseConverter;
60     _doubletFrequenciesCache = doubletFrequenciesCache;
61     if (_comparer.Compare(minFrequencyToCompress, _one) < 0)
62     {
63         minFrequencyToCompress = _one;
64     }
65     _minFrequencyToCompress = minFrequencyToCompress;
66     _doInitialFrequenciesIncrement = doInitialFrequenciesIncrement;
67     ResetMaxDoublet();
68 }
69
70 [MethodImpl(MethodImplOptions.AggressiveInlining)]
71 public override TLink Convert(IList<TLink> source) =>
72     ↳ _baseConverter.Convert(Compress(source));
73
74 /// <remarks>
75 /// Original algorithm idea: https://en.wikipedia.org/wiki/Byte\_pair\_encoding .
76 /// Faster version (doublets' frequencies dictionary is not recreated).
77 /// </remarks>
78 [MethodImpl(MethodImplOptions.AggressiveInlining)]
79 private IList<TLink> Compress(IList<TLink> sequence)
80 {
81     if (sequence.IsNullOrEmpty())
82     {
83         return null;
84     }
85     if (sequence.Count == 1)
86     {
87         return sequence;
88     }
89     if (sequence.Count == 2)
90     {
91         return new[] { _links.GetOrCreate(sequence[0], sequence[1]) };
92     }
93     // TODO: arraypool with min size (to improve cache locality) or stackalloc with Sigil
94     var copy = new HalfDoublet[sequence.Count];
95     Doublet<TLink> doublet = default;
96     for (var i = 1; i < sequence.Count; i++)
97     {
98         doublet = new Doublet<TLink>(sequence[i - 1], sequence[i]);
99         LinkFrequency<TLink> data;
100         if (_doInitialFrequenciesIncrement)
101         {
102             data = _doubletFrequenciesCache.IncrementFrequency(ref doublet);
103         }
104     }

```

```

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

```

```

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 ||
213     ↪ (maxFrequency == frequency && doublet.Source + doublet.Target < /* gives better
214     ↪ compression string data (and gives collisions quickly) */ _maxDoublet.Source +
215     ↪ _maxDoublet.Target)))
216     if (_comparer.Compare(frequency, _minFrequencyToCompress) > 0 &&
217         (_comparer.Compare(maxFrequency, frequency) < 0 ||
218         ↪ (_equalityComparer.Equals(maxFrequency, frequency) &&
219         ↪ _comparer.Compare(Arithmetic.Add(doublet.Source, doublet.Target),
220         ↪ Arithmetic.Add(_maxDoublet.Source, _maxDoublet.Target)) > 0))) /* gives
221         ↪ better stability and better compression on sequent data and even on random
222         ↪ numbers data (but gives collisions anyway) */
223     {
224         _maxDoublet = doublet;
225         _maxDoubletData = data;
226     }
227 }
228 }
229 }
230 }
231 }

```

1.124 ./csharp/Platform.Data.Doublets/Sequences/Converters/LinksListToSequenceConverterBase.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Sequences.Converters
8 {
9     public abstract class LinksListToSequenceConverterBase<TLink> : LinksOperatorBase<TLink>,
10     ↪ IConverter<IList<TLink>, TLink>
11     {
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         protected LinksListToSequenceConverterBase(ILinks<TLink> links) : base(links) { }
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public abstract TLink Convert(IList<TLink> source);
17     }
18 }

```

1.125 ./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;
54                 var currentLevel = levels[0];
55                 var previousLevel = levels[0];
56                 var skipOnce = false;
57                 var w = 0;
58                 for (var i = 1; i < length; i++)
59                 {
60                     if (_equalityComparer.Equals(currentLevel, levels[i]))
61                     {
62                         levelRepeat++;
63                         skipOnce = false;
64                         if (levelRepeat == 2)
65                         {
66                             sequence[w] = _links.GetOrCreate(sequence[i - 1], sequence[i]);
67                             var newLevel = i >= length - 1 ?
68                                 GetPreviousLowerThanCurrentOrCurrent(previousLevel,
69                                     ↪ currentLevel) :
70                                 i < 2 ?
71                                     GetNextLowerThanCurrentOrCurrent(currentLevel, levels[i + 1]) :
72                                     GetGreatestNeighbourLowerThanCurrentOrCurrent(previousLevel,
73                                         ↪ currentLevel, levels[i + 1]);
74                             levels[w] = newLevel;
75                             previousLevel = currentLevel;
76                             w++;
77                             levelRepeat = 0;
78                             skipOnce = true;
79                         }
80                     }
81                     else if (i == length - 1)

```

```

73         {
74             sequence[w] = sequence[i];
75             levels[w] = levels[i];
76             w++;
77         }
78     }
79     else
80     {
81         currentLevel = levels[i];
82         levelRepeat = 1;
83         if (skipOnce)
84         {
85             skipOnce = false;
86         }
87         else
88         {
89             sequence[w] = sequence[i - 1];
90             levels[w] = levels[i - 1];
91             previousLevel = levels[w];
92             w++;
93         }
94         if (i == length - 1)
95         {
96             sequence[w] = sequence[i];
97             levels[w] = levels[i];
98             w++;
99         }
100     }
101     }
102     length = w;
103 }
104 return _links.GetOrCreate(sequence[0], sequence[1]);
105 }
106
107 [MethodImpl(MethodImplOptions.AggressiveInlining)]
108 private static TLink GetGreatestNeighbourLowerThanCurrentOrCurrent(TLink previous, TLink
    ↪ current, TLink next)
109 {
110     return _comparer.Compare(previous, next) > 0
111         ? _comparer.Compare(previous, current) < 0 ? previous : current
112         : _comparer.Compare(next, current) < 0 ? next : current;
113 }
114
115 [MethodImpl(MethodImplOptions.AggressiveInlining)]
116 private static TLink GetNextLowerThanCurrentOrCurrent(TLink current, TLink next) =>
    ↪ _comparer.Compare(next, current) < 0 ? next : current;
117
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 private static TLink GetPreviousLowerThanCurrentOrCurrent(TLink previous, TLink current)
    ↪ => _comparer.Compare(previous, current) < 0 ? previous : current;
120 }
121 }

```

1.126 ./csharp/Platform.Data.Doublets/Sequences/Converters/SequenceToItsLocalElementLevelsConverter.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Sequences.Converters
8 {
9     public class SequenceToItsLocalElementLevelsConverter<TLink> : LinksOperatorBase<TLink>,
    ↪ IConverter<IList<TLink>>
10     {
11         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
12
13         private readonly IConverter<Doublet<TLink>, TLink> _linkToItsFrequencyToNumberConveter;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public SequenceToItsLocalElementLevelsConverter(ILinks<TLink> links,
    ↪ IConverter<Doublet<TLink>, TLink> linkToItsFrequencyToNumberConveter) : base(links)
    ↪ => _linkToItsFrequencyToNumberConveter = linkToItsFrequencyToNumberConveter;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public IList<TLink> Convert(IList<TLink> sequence)
20         {
21             var levels = new TLink[sequence.Count];
22             levels[0] = GetFrequencyNumber(sequence[0], sequence[1]);

```



```

23     for (var i = 1; i < sequence.Count - 1; i++)
24     {
25         var previous = GetFrequencyNumber(sequence[i - 1], sequence[i]);
26         var next = GetFrequencyNumber(sequence[i], sequence[i + 1]);
27         levels[i] = _comparer.Compare(previous, next) > 0 ? previous : next;
28     }
29     levels[levels.Length - 1] = GetFrequencyNumber(sequence[sequence.Count - 2],
30     ↪ sequence[sequence.Count - 1]);
31     return levels;
32 }
33 [MethodImpl(MethodImplOptions.AggressiveInlining)]
34 public TLink GetFrequencyNumber(TLink source, TLink target) =>
35     ↪ _linkToItsFrequencyToNumberConveter.Convert(new Doublet<TLink>(source, target));
36 }

```

1.127 ./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    }

```

1.128 ./csharp/Platform.Data.Doublets/Sequences/CriterionMatchers/MarkedSequenceCriterionMatcher.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Interfaces;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Sequences.CriterionMatchers
8 {
9     public class MarkedSequenceCriterionMatcher<TLink> : ICriterionMatcher<TLink>
10    {
11        private static readonly EqualityComparer<TLink> _equalityComparer =
12        ↪ EqualityComparer<TLink>.Default;
13
14        private readonly ILinks<TLink> _links;
15        private readonly TLink _sequenceMarkerLink;
16
17        [MethodImpl(MethodImplOptions.AggressiveInlining)]
18        public MarkedSequenceCriterionMatcher(ILinks<TLink> links, TLink sequenceMarkerLink)
19        {
20            _links = links;
21            _sequenceMarkerLink = sequenceMarkerLink;
22        }
23
24        [MethodImpl(MethodImplOptions.AggressiveInlining)]
25        public bool IsMatched(TLink sequenceCandidate)
26        => _equalityComparer.Equals(_links.GetSource(sequenceCandidate), _sequenceMarkerLink)
27        || !_equalityComparer.Equals(_links.SearchOrDefault(_sequenceMarkerLink,
28        ↪ sequenceCandidate), _links.Constants.Null);
29    }

```

1.129 ./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>,
    ↳ ISequenceAppender<TLink>
12 {
13     private static readonly EqualityComparer<TLink> _equalityComparer =
        ↳ EqualityComparer<TLink>.Default;
14
15     private readonly IStack<TLink> _stack;
16     private readonly ISequenceHeightProvider<TLink> _heightProvider;
17
18     [MethodImpl(MethodImplOptions.AggressiveInlining)]
19     public DefaultSequenceAppender(ILinks<TLink> links, IStack<TLink> stack,
        ↳ ISequenceHeightProvider<TLink> heightProvider)
        : base(links)
20     {
21         _stack = stack;
22         _heightProvider = heightProvider;
23     }
24
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     public TLink Append(TLink sequence, TLink appendant)
27     {
28         var cursor = sequence;
29         var links = _links;
30         while (!_equalityComparer.Equals(_heightProvider.Get(cursor), default))
31         {
32             var source = links.GetSource(cursor);
33             var target = links.GetTarget(cursor);
34             if (_equalityComparer.Equals(_heightProvider.Get(source),
        ↳ _heightProvider.Get(target)))
35             {
36                 break;
37             }
38             else
39             {
40                 _stack.Push(source);
41                 cursor = target;
42             }
43         }
44         var left = cursor;
45         var right = appendant;
46         while (!_equalityComparer.Equals(cursor = _stack.PopOrDefault(),
        ↳ links.Constants.Null))
47         {
48             right = links.GetOrCreate(left, right);
49             left = cursor;
50         }
51         return links.GetOrCreate(left, right);
52     }
53 }
54
55 }

```

1.130 ./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>>>>
            ↳ _duplicateFragmentsProvider;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public DuplicateSegmentsCounter(IProvider<IList<KeyValuePair<IList<TLink>,
            ↳ IList<TLink>>>> duplicateFragmentsProvider) => _duplicateFragmentsProvider =
            ↳ duplicateFragmentsProvider;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public int Count() => _duplicateFragmentsProvider.Get().Sum(x => x.Value.Count);
19     }
20 }

```

1.131 ./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             [MethodImpl(MethodImplOptions.AggressiveInlining)]
62             public int Compare(KeyValuePair<IList<TLink>, IList<TLink>> left,
63                 ↳ KeyValuePair<IList<TLink>, IList<TLink>> right)
64             {
65                 var intermediateResult = _listComparer.Compare(left.Key, right.Key);
66                 if (intermediateResult == 0)
67                 {
68                     intermediateResult = _listComparer.Compare(left.Value, right.Value);
69                 }
70                 return intermediateResult;
71             }
72         }
73
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]
75         public DuplicateSegmentsProvider(ILinks<TLink> links, ILinks<TLink> sequences)
76             : base(minimumStringSegmentLength: 2)
77         {
78             _links = links;
79             _sequences = sequences;
80         }
81
82         [MethodImpl(MethodImplOptions.AggressiveInlining)]
83         public IList<KeyValuePair<IList<TLink>, IList<TLink>>> Get()

```

```

71 {
72     _groups = new HashSet<KeyValuePair<IList<TLink>,
73         ↳ IList<TLink>>>(Default<ItemEqualityComparer>.Instance);
74     var links = _links;
75     var count = links.Count();
76     _visited = new BitString(_addressToInt64Converter.Convert(count) + 1L);
77     links.Each(link =>
78     {
79         var linkIndex = links.GetIndex(link);
80         var linkBitIndex = _addressToInt64Converter.Convert(linkIndex);
81         var constants = links.Constants;
82         if (!_visited.Get(linkBitIndex))
83         {
84             var sequenceElements = new List<TLink>();
85             var filler = new ListFiller<TLink, TLink>(sequenceElements, constants.Break);
86             _sequences.Each(filler.AddSkipFirstAndReturnConstant, new
87                 ↳ LinkAddress<TLink>(linkIndex));
88             if (sequenceElements.Count > 2)
89             {
90                 WalkAll(sequenceElements);
91             }
92             return constants.Continue;
93         });
94     var resultList = _groups.ToList();
95     var comparer = Default<ItemComparer>.Instance;
96     resultList.Sort(comparer);
97     #if DEBUG
98     foreach (var item in resultList)
99     {
100         PrintDuplicates(item);
101     }
102     #endif
103     return resultList;
104 }
105 [MethodImpl(MethodImplOptions.AggressiveInlining)]
106 protected override Segment<TLink> CreateSegment(IList<TLink> elements, int offset, int
107     ↳ length) => new Segment<TLink>(elements, offset, length);
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(),
115             ↳ duplicates));
116     }
117 }
118 [MethodImpl(MethodImplOptions.AggressiveInlining)]
119 private List<TLink> CollectDuplicatesForSegment(Segment<TLink> segment)
120 {
121     var duplicates = new List<TLink>();
122     var readAsElement = new HashSet<TLink>();
123     var restrictions = segment.ShiftRight();
124     var constants = _links.Constants;
125     restrictions[0] = constants.Any;
126     _sequences.Each(sequence =>
127     {
128         var sequenceIndex = sequence[constants.IndexPart];
129         duplicates.Add(sequenceIndex);
130         readAsElement.Add(sequenceIndex);
131         return constants.Continue;
132     }, restrictions);
133     if (duplicates.Any(x => _visited.Get(_addressToInt64Converter.Convert(x))))
134     {
135         return new List<TLink>();
136     }
137     foreach (var duplicate in duplicates)
138     {
139         var duplicateBitIndex = _addressToInt64Converter.Convert(duplicate);
140         _visited.Set(duplicateBitIndex);
141     }
142     if (_sequences is Sequences sequencesExperiments)
143     {

```

```

144         var partiallyMatched = sequencesExperiments.GetAllPartiallyMatchingSequences4((H
            ↪ ashSet<ulong>)(object)readAsElement,
            ↪ (IList<ulong>)segment);
145     foreach (var partiallyMatchedSequence in partiallyMatched)
146     {
147         var sequenceIndex =
            ↪ _uInt64ToAddressConverter.Convert(partiallyMatchedSequence);
            duplicates.Add(sequenceIndex);
148     }
149 }
150 }
151 duplicates.Sort();
152 return duplicates;
153 }
154
155 [MethodImpl(MethodImplOptions.AggressiveInlining)]
156 private void PrintDuplicates(KeyValuePair<IList<TLink>, IList<TLink>> duplicatesItem)
157 {
158     if (!(_links is ILinks<ulong> ulongLinks))
159     {
160         return;
161     }
162     var duplicatesKey = duplicatesItem.Key;
163     var keyString = UnicodeMap.FromLinksToString((IList<ulong>)duplicatesKey);
164     Console.WriteLine($"> {keyString} ({string.Join(", ", duplicatesKey)}");
165     var duplicatesList = duplicatesItem.Value;
166     for (int i = 0; i < duplicatesList.Count; i++)
167     {
168         var sequenceIndex = _addressToUInt64Converter.Convert(duplicatesList[i]);
169         var formattedSequenceStructure = ulongLinks.FormatStructure(sequenceIndex, x =>
            ↪ Point<ulong>.IsPartialPoint(x), (sb, link) => _ =
            ↪ UnicodeMap.IsCharLink(link.Index) ?
            ↪ sb.Append(UnicodeMap.FromLinkToChar(link.Index)) : sb.Append(link.Index));
170         Console.WriteLine(formattedSequenceStructure);
171         var sequenceString = UnicodeMap.FromSequenceLinkToString(sequenceIndex,
            ↪ ulongLinks);
172         Console.WriteLine(sequenceString);
173     }
174     Console.WriteLine();
175 }
176 }
177 }

```

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

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Interfaces;
5  using Platform.Numbers;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Sequences.Frequencies.Cache
10 {
11     /// <remarks>
12     /// Can be used to operate with many CompressingConverters (to keep global frequencies data
13     ↪ between them).
14     /// TODO: Extract interface to implement frequencies storage inside Links storage
15     /// </remarks>
16     public class LinkFrequenciesCache<TLink> : LinksOperatorBase<TLink>
17     {
18         private static readonly EqualityComparer<TLink> _equalityComparer =
            ↪ 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 }

```

```

34 [MethodImpl(MethodImplOptions.AggressiveInlining)]
35 public LinkFrequency<TLink> GetFrequency(TLink source, TLink target)
36 {
37     var doublet = new Doublet<TLink>(source, target);
38     return GetFrequency(ref doublet);
39 }
40
41 [MethodImpl(MethodImplOptions.AggressiveInlining)]
42 public LinkFrequency<TLink> GetFrequency(ref Doublet<TLink> doublet)
43 {
44     _doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data);
45     return data;
46 }
47
48 [MethodImpl(MethodImplOptions.AggressiveInlining)]
49 public void IncrementFrequencies(IList<TLink> sequence)
50 {
51     for (var i = 1; i < sequence.Count; i++)
52     {
53         IncrementFrequency(sequence[i - 1], sequence[i]);
54     }
55 }
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 public LinkFrequency<TLink> IncrementFrequency(TLink source, TLink target)
59 {
60     var doublet = new Doublet<TLink>(source, target);
61     return IncrementFrequency(ref doublet);
62 }
63
64 [MethodImpl(MethodImplOptions.AggressiveInlining)]
65 public void PrintFrequencies(IList<TLink> sequence)
66 {
67     for (var i = 1; i < sequence.Count; i++)
68     {
69         PrintFrequency(sequence[i - 1], sequence[i]);
70     }
71 }
72
73 [MethodImpl(MethodImplOptions.AggressiveInlining)]
74 public void PrintFrequency(TLink source, TLink target)
75 {
76     var number = GetFrequency(source, target).Frequency;
77     Console.WriteLine("{0},{1} - {2}", source, target, number);
78 }
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 public LinkFrequency<TLink> IncrementFrequency(ref Doublet<TLink> doublet)
82 {
83     if (_doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data))
84     {
85         data.IncrementFrequency();
86     }
87     else
88     {
89         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     }
98     return data;
99 }
100
101 [MethodImpl(MethodImplOptions.AggressiveInlining)]
102 public void ValidateFrequencies()
103 {
104     foreach (var entry in _doubletsCache)
105     {
106         var value = entry.Value;
107         var linkIndex = value.Link;
108         if (!_equalityComparer.Equals(linkIndex, default))
109         {
110             var frequency = value.Frequency;
111             var count = _frequencyCounter.Count(linkIndex);
112             // 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     }
120     //else
121     //{
122     //    if (value.Frequency > 0)
123     //    {
124     //        var frequency = value.Frequency;
125     //        linkIndex = _createLink(entry.Key.Source, entry.Key.Target);
126     //        var count = _countLinkFrequency(linkIndex);
127     //        if ((frequency > count && frequency - count > 1) || (count > frequency
128     //            ↪ && count - frequency > 1))
129     //            throw new InvalidOperationException("Frequencies validation
130     //            ↪ failed.");
131     //    }
132     //}
133 }

```

1.133 ./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 }

```

1.134 ./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 }

```

```

15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public TLink Convert(Doublet<TLink> source) => _cache.GetFrequency(ref source).Frequency;
17     }
18 }

```

1.135 ./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 }

```

1.136 ./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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public SequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links, TLink sequenceLink,
24             ↳ TLink symbol)
25         {
26             _links = links;
27             _sequenceLink = sequenceLink;
28             _symbol = symbol;
29             _total = default;
30         }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public virtual TLink Count()
34         {
35             if (_comparer.Compare(_total, default) > 0)
36             {
37                 return _total;
38             }
39             StopableSequenceWalker.WalkRight(_sequenceLink, _links.GetSource, _links.GetTarget,
40                 ↳ IsElement, VisitElement);
41             return _total;
42         }
43     }
44 }

```



```

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 }

```

1.137 ./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 }

```

1.138 ./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,
    ↪ ICriterionMatcher<TLink> markedSequenceMatcher, TLink symbol)
15             : base(links, symbol)
16             => _markedSequenceMatcher = markedSequenceMatcher;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override void CountSequenceSymbolFrequency(TLink link)
20         {
21             var symbolFrequencyCounter = new
    ↪ MarkedSequenceSymbolFrequencyOneOffCounter<TLink>(_links,
    ↪ _markedSequenceMatcher, link, _symbol);
22             _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
23         }
24     }
25 }

```

1.139 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyCounte

```

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 }

```

1.140 ./csharp/Platform.Data.Doublets/Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyOneOffCounter.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Interfaces;
4 using Platform.Numbers;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
9 {
10     public class TotalSequenceSymbolFrequencyOneOffCounter<TLink> : ICounter<TLink>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
13             ↳ EqualityComparer<TLink>.Default;
14         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
15
16         protected readonly ILinks<TLink> _links;
17         protected readonly TLink _symbol;
18         protected readonly HashSet<TLink> _visits;
19         protected TLink _total;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public TotalSequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links, TLink symbol)
23         {
24             _links = links;
25             _symbol = symbol;
26             _visits = new HashSet<TLink>();
27             _total = default;
28         }
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public TLink Count()
32         {
33             if (_comparer.Compare(_total, default) > 0 || _visits.Count > 0)
34             {
35                 return _total;
36             }
37             CountCore(_symbol);
38             return _total;
39         }
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         private void CountCore(TLink link)
43         {
44             var any = _links.Constants.Any;
45             if (_equalityComparer.Equals(_links.Count(any, link), default))
46             {
47                 CountSequenceSymbolFrequency(link);
48             }
49             else
50             {
51                 _links.Each(EachElementHandler, any, link);
52             }
53         }
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         protected virtual void CountSequenceSymbolFrequency(TLink link)
57         {
58             var symbolFrequencyCounter = new SequenceSymbolFrequencyOneOffCounter<TLink>(_links,
59                 ↳ link, _symbol);
60             _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
61         }
62     }
63 }

```

```

60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     private TLink EachElementHandler(IList<TLink> doublet)
63     {
64         var constants = _links.Constants;
65         var doubletIndex = doublet[constants.IndexPart];
66         if (_visits.Add(doubletIndex))
67         {
68             CountCore(doubletIndex);
69         }
70         return constants.Continue;
71     }
72 }
73 }

```

1.141 ./csharp/Platform.Data.Doublets/Sequences/HeightProviders/CachedSequenceHeightProvider.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Converters;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Sequences.HeightProviders
9  {
10     public class CachedSequenceHeightProvider<TLink> : ISequenceHeightProvider<TLink>
11     {
12         private static readonly EqualityComparer<TLink> _equalityComparer =
13             ⇨ EqualityComparer<TLink>.Default;
14
15         private readonly TLink _heightPropertyMarker;
16         private readonly ISequenceHeightProvider<TLink> _baseHeightProvider;
17         private readonly IConverter<TLink> _addressToUnaryNumberConverter;
18         private readonly IConverter<TLink> _unaryNumberToAddressConverter;
19         private readonly IProperties<TLink, TLink, TLink> _propertyOperator;
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         public CachedSequenceHeightProvider(
23             ISequenceHeightProvider<TLink> baseHeightProvider,
24             IConverter<TLink> addressToUnaryNumberConverter,
25             IConverter<TLink> unaryNumberToAddressConverter,
26             TLink heightPropertyMarker,
27             IProperties<TLink, TLink, TLink> propertyOperator)
28         {
29             _heightPropertyMarker = heightPropertyMarker;
30             _baseHeightProvider = baseHeightProvider;
31             _addressToUnaryNumberConverter = addressToUnaryNumberConverter;
32             _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
33             _propertyOperator = propertyOperator;
34         }
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public TLink Get(TLink sequence)
38         {
39             TLink height;
40             var heightValue = _propertyOperator.GetValue(sequence, _heightPropertyMarker);
41             if (_equalityComparer.Equals(heightValue, default))
42             {
43                 height = _baseHeightProvider.Get(sequence);
44                 heightValue = _addressToUnaryNumberConverter.Convert(height);
45                 _propertyOperator.SetValue(sequence, _heightPropertyMarker, heightValue);
46             }
47             else
48             {
49                 height = _unaryNumberToAddressConverter.Convert(heightValue);
50             }
51             return height;
52         }
53     }
54 }

```

1.142 ./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>,
    ↪     ISequenceHeightProvider<TLink>
10     {
11         private readonly ICriterionMatcher<TLink> _elementMatcher;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public DefaultSequenceRightHeightProvider(ILinks<TLink> links, ICriterionMatcher<TLink>
    ↪         elementMatcher) : base(links) => _elementMatcher = elementMatcher;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public TLink Get(TLink sequence)
18         {
19             var height = default(TLink);
20             var pairOrElement = sequence;
21             while (!_elementMatcher.IsMatched(pairOrElement))
22             {
23                 pairOrElement = _links.GetTarget(pairOrElement);
24                 height = Arithmetic.Increment(height);
25             }
26             return height;
27         }
28     }
29 }

```

1.143 ./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 }

```

1.144 ./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 =
    ↪         EqualityComparer<TLink>.Default;
12
13         private readonly LinkFrequenciesCache<TLink> _cache;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public CachedFrequencyIncrementingSequenceIndex(LinkFrequenciesCache<TLink> cache) =>
    ↪         _cache = cache;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public bool Add(IList<TLink> sequence)
20         {
21             var indexed = true;
22             var i = sequence.Count;
23             while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
    ↪             { }
24             for (; i >= 1; i--)
25             {
26                 _cache.IncrementFrequency(sequence[i - 1], sequence[i]);
27             }
28             return indexed;
29         }
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 }

```

1.145 ./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)]
29         public override bool Add(ICollection<TLink> sequence)
30         {
31             var indexed = true;
32             var i = sequence.Count;
33             while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
34                 ↳ { }
35             for (; i >= 1; i--)
36             {
37                 Increment(_links.GetOrCreate(sequence[i - 1], sequence[i]));
38             }
39             return indexed;
40         }
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         private bool IsIndexedWithIncrement(TLink source, TLink target)
44         {
45             var link = _links.SearchOrCreate(source, target);
46             var indexed = !_equalityComparer.Equals(link, default);
47             if (indexed)
48             {
49                 Increment(link);
50             }
51         }
52     }
53 }

```

```

47         return indexed;
48     }
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     private void Increment(TLink link)
52     {
53         var previousFrequency = _frequencyPropertyOperator.Get(link);
54         var frequency = _frequencyIncrementer.Increment(previousFrequency);
55         _frequencyPropertyOperator.Set(link, frequency);
56     }
57 }
58 }

```

1.146 ./csharp/Platform.Data.Doublets/Sequences/Indexes/ISequenceIndex.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Sequences.Indexes
7  {
8      public interface ISequenceIndex<TLink>
9      {
10         /// <summary>
11         /// Индексирует последовательность глобально, и возвращает значение,
12         /// определяющие была ли запрошенная последовательность проиндексирована ранее.
13         /// </summary>
14         /// <param name="sequence">Последовательность для индексации.</param>
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         bool Add(IList<TLink> sequence);
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         bool MightContain(IList<TLink> sequence);
20     }
21 }

```

1.147 ./csharp/Platform.Data.Doublets/Sequences/Indexes/SequenceIndex.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Sequences.Indexes
7  {
8      public class SequenceIndex<TLink> : LinksOperatorBase<TLink>, ISequenceIndex<TLink>
9      {
10         private static readonly EqualityComparer<TLink> _equalityComparer =
11             ↳ EqualityComparer<TLink>.Default;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public SequenceIndex(ILinks<TLink> links) : base(links) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public virtual bool Add(IList<TLink> sequence)
18         {
19             var indexed = true;
20             var i = sequence.Count;
21             while (--i >= 1 && (indexed =
22                 ↳ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
23                 ↳ default))) { }
24             for (; i >= 1; i--)
25             {
26                 _links.GetOrCreate(sequence[i - 1], sequence[i]);
27             }
28             return indexed;
29         }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public virtual bool MightContain(IList<TLink> sequence)
33         {
34             var indexed = true;
35             var i = sequence.Count;
36             while (--i >= 1 && (indexed =
37                 ↳ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
38                 ↳ default))) { }
39             return indexed;
40         }
41     }
42 }

```

1.148 ./csharp/Platform.Data.Doublets/Sequences/Indexes/SynchronizedSequenceIndex.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Sequences.Indexes
7  {
8      public class SynchronizedSequenceIndex<TLink> : ISequenceIndex<TLink>
9      {
10         private static readonly EqualityComparer<TLink> _equalityComparer =
11             ↳ EqualityComparer<TLink>.Default;
12
13         private readonly ISynchronizedLinks<TLink> _links;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public SynchronizedSequenceIndex(ISynchronizedLinks<TLink> links) => _links = links;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public bool Add(IList<TLink> sequence)
20         {
21             var indexed = true;
22             var i = sequence.Count;
23             var links = _links.Unsync;
24             _links.SyncRoot.ExecuteReadOperation(() =>
25             {
26                 while (--i >= 1 && (indexed =
27                     ↳ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
28                     ↳ sequence[i]), default))) { }
29             });
30             if (!indexed)
31             {
32                 _links.SyncRoot.ExecuteWriteOperation(() =>
33                 {
34                     for (; i >= 1; i--)
35                     {
36                         links.GetOrCreate(sequence[i - 1], sequence[i]);
37                     }
38                 });
39             }
40             return indexed;
41         }
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         public bool MightContain(IList<TLink> sequence)
45         {
46             var links = _links.Unsync;
47             return _links.SyncRoot.ExecuteReadOperation(() =>
48             {
49                 var indexed = true;
50                 var i = sequence.Count;
51                 while (--i >= 1 && (indexed =
52                     ↳ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
53                     ↳ sequence[i]), default))) { }
54                 return indexed;
55             });
56         }
57     }
58 }

```

1.149 ./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 }

```

1.150 ./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, (ulong)sequence.Length - 1);
43             });
44         }
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         private ulong[] CreateAllVariants2Core(ulong[] sequence, ulong startAt, ulong stopAt)
48         {
49             if ((stopAt - startAt) == 0)
50             {
51                 return new[] { sequence[startAt] };
52             }
53             if ((stopAt - startAt) == 1)
54             {
55                 return new[] { Links.Unsync.GetOrCreate(sequence[startAt], sequence[stopAt]) };
56             }
57             var variants = new ulong[Platform.Numbers.Math.Catalan(stopAt - startAt)];
58             var last = 0;
59             for (var splitter = startAt; splitter < stopAt; splitter++)
60             {
61                 var left = CreateAllVariants2Core(sequence, startAt, splitter);
62                 var right = CreateAllVariants2Core(sequence, splitter + 1, stopAt);
63                 for (var i = 0; i < left.Length; i++)
64                 {
65                     for (var j = 0; j < right.Length; j++)
66                     {
67                         var variant = Links.Unsync.GetOrCreate(left[i], right[j]);
68                         if (variant == Constants.Null)
69                         {
70                             throw new NotImplementedException("Creation cancellation is not
71                                 ↪ implemented.");
72                         }
73                         variants[last++] = variant;
74                     }
75                 }
76             }
77             return variants;
78         }
79     }
80 }

```



```

78 [MethodImpl(MethodImplOptions.AggressiveInlining)]
79 public List<ulong> CreateAllVariants1(params ulong[] sequence)
80 {
81     return _sync.ExecuteWriteOperation(() =>
82     {
83         if (sequence.IsNullOrEmpty())
84         {
85             return new List<ulong>();
86         }
87         Links.Unsync.EnsureLinkExists(sequence);
88         if (sequence.Length == 1)
89         {
90             return new List<ulong> { sequence[0] };
91         }
92         var results = new
93             ↳ List<ulong>((int)Platform.Numbers.Math.Catalan((ulong)sequence.Length));
94         return CreateAllVariants1Core(sequence, results);
95     });
96 }
97
98 [MethodImpl(MethodImplOptions.AggressiveInlining)]
99 private List<ulong> CreateAllVariants1Core(ulong[] sequence, List<ulong> results)
100 {
101     if (sequence.Length == 2)
102     {
103         var link = Links.Unsync.GetOrCreate(sequence[0], sequence[1]);
104         if (link == Constants.Null)
105         {
106             throw new NotImplementedException("Creation cancellation is not
107                 ↳ implemented.");
108         }
109         results.Add(link);
110         return results;
111     }
112     var innerSequenceLength = sequence.Length - 1;
113     var innerSequence = new ulong[innerSequenceLength];
114     for (var li = 0; li < innerSequenceLength; li++)
115     {
116         var link = Links.Unsync.GetOrCreate(sequence[li], sequence[li + 1]);
117         if (link == Constants.Null)
118         {
119             throw new NotImplementedException("Creation cancellation is not
120                 ↳ implemented.");
121         }
122         for (var isi = 0; isi < li; isi++)
123         {
124             innerSequence[isi] = sequence[isi];
125         }
126         innerSequence[li] = link;
127         for (var isi = li + 1; isi < innerSequenceLength; isi++)
128         {
129             innerSequence[isi] = sequence[isi + 1];
130         }
131         CreateAllVariants1Core(innerSequence, results);
132     }
133     return results;
134 }
135
136 #endregion
137
138 [MethodImpl(MethodImplOptions.AggressiveInlining)]
139 public HashSet<ulong> Each1(params ulong[] sequence)
140 {
141     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
142     Each1(link =>
143     {
144         if (!visitedLinks.Contains(link))
145         {
146             visitedLinks.Add(link); // изучить почему случаются повторы
147         }
148         return true;
149     }, sequence);
150     return visitedLinks;
151 }
152
153 [MethodImpl(MethodImplOptions.AggressiveInlining)]
154 private void Each1(Func<ulong, bool> handler, params ulong[] sequence)

```

```

153 {
154     if (sequence.Length == 2)
155     {
156         Links.Unsync.Each(sequence[0], sequence[1], handler);
157     }
158     else
159     {
160         var innerSequenceLength = sequence.Length - 1;
161         for (var li = 0; li < innerSequenceLength; li++)
162         {
163             var left = sequence[li];
164             var right = sequence[li + 1];
165             if (left == 0 && right == 0)
166             {
167                 continue;
168             }
169             var linkIndex = li;
170             ulong[] innerSequence = null;
171             Links.Unsync.Each(doublet =>
172             {
173                 if (innerSequence == null)
174                 {
175                     innerSequence = new ulong[innerSequenceLength];
176                     for (var isi = 0; isi < linkIndex; isi++)
177                     {
178                         innerSequence[isi] = sequence[isi];
179                     }
180                     for (var isi = linkIndex + 1; isi < innerSequenceLength; isi++)
181                     {
182                         innerSequence[isi] = sequence[isi + 1];
183                     }
184                 }
185                 innerSequence[linkIndex] = doublet[Constants.IndexPart];
186                 Each1(handler, innerSequence);
187                 return Constants.Continue;
188             }, Constants.Any, left, right);
189         }
190     }
191 }
192
193 [MethodImpl(MethodImplOptions.AggressiveInlining)]
194 public HashSet<ulong> EachPart(params ulong[] sequence)
195 {
196     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
197     EachPartCore(link =>
198     {
199         var linkIndex = link[Constants.IndexPart];
200         if (!visitedLinks.Contains(linkIndex))
201         {
202             visitedLinks.Add(linkIndex); // изучить почему случаются повторы
203         }
204         return Constants.Continue;
205     }, sequence);
206     return visitedLinks;
207 }
208
209 [MethodImpl(MethodImplOptions.AggressiveInlining)]
210 public void EachPart(Func<IList<LinkIndex>, LinkIndex> handler, params ulong[] sequence)
211 {
212     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
213     EachPartCore(link =>
214     {
215         var linkIndex = link[Constants.IndexPart];
216         if (!visitedLinks.Contains(linkIndex))
217         {
218             visitedLinks.Add(linkIndex); // изучить почему случаются повторы
219             return handler(new LinkAddress<LinkIndex>(linkIndex));
220         }
221         return Constants.Continue;
222     }, sequence);
223 }
224
225 [MethodImpl(MethodImplOptions.AggressiveInlining)]
226 private void EachPartCore(Func<IList<LinkIndex>, LinkIndex> handler, params ulong[]
↪ sequence)
227 {
228     if (sequence.IsNullOrEmpty())
229     {

```

```

230         return;
231     }
232     Links.EnsureLinkIsAnyOrExists(sequence);
233     if (sequence.Length == 1)
234     {
235         var link = sequence[0];
236         if (link > 0)
237         {
238             handler(new LinkAddress<LinkIndex>(link));
239         }
240         else
241         {
242             Links.Each(Constants.Any, Constants.Any, handler);
243         }
244     }
245     else if (sequence.Length == 2)
246     {
247         //_links.Each(sequence[0], sequence[1], handler);
248         //  o_|      x_o ...
249         // x_|      |__|
250         Links.Each(sequence[1], Constants.Any, doublet =>
251         {
252             var match = Links.SearchOrDefault(sequence[0], doublet);
253             if (match != Constants.Null)
254             {
255                 handler(new LinkAddress<LinkIndex>(match));
256             }
257             return true;
258         });
259         // |_x      ... x_o
260         // |_o      |__|
261         Links.Each(Constants.Any, sequence[0], doublet =>
262         {
263             var match = Links.SearchOrDefault(doublet, sequence[1]);
264             if (match != 0)
265             {
266                 handler(new LinkAddress<LinkIndex>(match));
267             }
268             return true;
269         });
270         //      . _x o _ .
271         //      |__|
272         PartialStepRight(x => handler(x), sequence[0], sequence[1]);
273     }
274     else
275     {
276         throw new NotImplementedException();
277     }
278 }
279
280 [MethodImpl(MethodImplOptions.AggressiveInlining)]
281 private void PartialStepRight(Action<IList<LinkIndex>> handler, ulong left, ulong right)
282 {
283     Links.Unsync.Each(Constants.Any, left, doublet =>
284     {
285         StepRight(handler, doublet, right);
286         if (left != doublet)
287         {
288             PartialStepRight(handler, doublet, right);
289         }
290         return true;
291     });
292 }
293
294 [MethodImpl(MethodImplOptions.AggressiveInlining)]
295 private void StepRight(Action<IList<LinkIndex>> handler, ulong left, ulong right)
296 {
297     Links.Unsync.Each(left, Constants.Any, rightStep =>
298     {
299         TryStepRightUp(handler, right, rightStep);
300         return true;
301     });
302 }
303
304 [MethodImpl(MethodImplOptions.AggressiveInlining)]
305 private void TryStepRightUp(Action<IList<LinkIndex>> handler, ulong right, ulong
↪ stepFrom)
306 {

```

```

307     var upStep = stepFrom;
308     var firstSource = Links.Unsync.GetTarget(upStep);
309     while (firstSource != right && firstSource != upStep)
310     {
311         upStep = firstSource;
312         firstSource = Links.Unsync.GetSource(upStep);
313     }
314     if (firstSource == right)
315     {
316         handler(new LinkAddress<LinkIndex>(stepFrom));
317     }
318 }
319
320 // TODO: Test
321 [MethodImpl(MethodImplOptions.AggressiveInlining)]
322 private void PartialStepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
323 {
324     Links.Unsync.Each(right, Constants.Any, doublet =>
325     {
326         StepLeft(handler, left, doublet);
327         if (right != doublet)
328         {
329             PartialStepLeft(handler, left, doublet);
330         }
331         return true;
332     });
333 }
334
335 [MethodImpl(MethodImplOptions.AggressiveInlining)]
336 private void StepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
337 {
338     Links.Unsync.Each(Constants.Any, right, leftStep =>
339     {
340         TryStepLeftUp(handler, left, leftStep);
341         return true;
342     });
343 }
344
345 [MethodImpl(MethodImplOptions.AggressiveInlining)]
346 private void TryStepLeftUp(Action<IList<LinkIndex>> handler, ulong left, ulong stepFrom)
347 {
348     var upStep = stepFrom;
349     var firstTarget = Links.Unsync.GetSource(upStep);
350     while (firstTarget != left && firstTarget != upStep)
351     {
352         upStep = firstTarget;
353         firstTarget = Links.Unsync.GetTarget(upStep);
354     }
355     if (firstTarget == left)
356     {
357         handler(new LinkAddress<LinkIndex>(stepFrom));
358     }
359 }
360
361 [MethodImpl(MethodImplOptions.AggressiveInlining)]
362 private bool StartsWith(ulong sequence, ulong link)
363 {
364     var upStep = sequence;
365     var firstSource = Links.Unsync.GetSource(upStep);
366     while (firstSource != link && firstSource != upStep)
367     {
368         upStep = firstSource;
369         firstSource = Links.Unsync.GetSource(upStep);
370     }
371     return firstSource == link;
372 }
373
374 [MethodImpl(MethodImplOptions.AggressiveInlining)]
375 private bool EndsWith(ulong sequence, ulong link)
376 {
377     var upStep = sequence;
378     var lastTarget = Links.Unsync.GetTarget(upStep);
379     while (lastTarget != link && lastTarget != upStep)
380     {
381         upStep = lastTarget;
382         lastTarget = Links.Unsync.GetTarget(upStep);
383     }
384     return lastTarget == link;
385 }

```

```

386 [MethodImpl(MethodImplOptions.AggressiveInlining)]
387 public List<ulong> GetAllMatchingSequences0(params ulong[] sequence)
388 {
389     return _sync.ExecuteReadOperation(() =>
390     {
391         var results = new List<ulong>();
392         if (sequence.Length > 0)
393         {
394             Links.EnsureLinkExists(sequence);
395             var firstElement = sequence[0];
396             if (sequence.Length == 1)
397             {
398                 results.Add(firstElement);
399                 return results;
400             }
401             if (sequence.Length == 2)
402             {
403                 var doublet = Links.SearchOrDefault(firstElement, sequence[1]);
404                 if (doublet != Constants.Null)
405                 {
406                     results.Add(doublet);
407                 }
408                 return results;
409             }
410             var linksInSequence = new HashSet<ulong>(sequence);
411             void handler(ICollection<LinkIndex> result)
412             {
413                 var resultIndex = result[Links.Constants.IndexPart];
414                 var filterPosition = 0;
415                 StopableSequenceWalker.WalkRight(resultIndex, Links.Unsync.GetSource,
416                     ↪ Links.Unsync.GetTarget,
417                     ↪ x => linksInSequence.Contains(x) || Links.Unsync.GetTarget(x) == x,
418                     ↪ x =>
419                     {
420                         if (filterPosition == sequence.Length)
421                         {
422                             filterPosition = -2; // Длиннее чем нужно
423                             return false;
424                         }
425                         if (x != sequence[filterPosition])
426                         {
427                             filterPosition = -1;
428                             return false; // Начинается иначе
429                         }
430                         filterPosition++;
431                     }
432                     return true;
433                 });
434                 if (filterPosition == sequence.Length)
435                 {
436                     results.Add(resultIndex);
437                 }
438             }
439             if (sequence.Length >= 2)
440             {
441                 StepRight(handler, sequence[0], sequence[1]);
442             }
443             var last = sequence.Length - 2;
444             for (var i = 1; i < last; i++)
445             {
446                 PartialStepRight(handler, sequence[i], sequence[i + 1]);
447             }
448             if (sequence.Length >= 3)
449             {
450                 StepLeft(handler, sequence[sequence.Length - 2],
451                     ↪ sequence[sequence.Length - 1]);
452             }
453         }
454         return results;
455     });
456 }
457 [MethodImpl(MethodImplOptions.AggressiveInlining)]
458 public HashSet<ulong> GetAllMatchingSequences1(params ulong[] sequence)
459 {
460     return _sync.ExecuteReadOperation(() =>
461     {

```

```

461     var results = new HashSet<ulong>();
462     if (sequence.Length > 0)
463     {
464         Links.EnsureLinkExists(sequence);
465         var firstElement = sequence[0];
466         if (sequence.Length == 1)
467         {
468             results.Add(firstElement);
469             return results;
470         }
471         if (sequence.Length == 2)
472         {
473             var doublet = Links.SearchOrDefault(firstElement, sequence[1]);
474             if (doublet != Constants.Null)
475             {
476                 results.Add(doublet);
477             }
478             return results;
479         }
480         var matcher = new Matcher(this, sequence, results, null);
481         if (sequence.Length >= 2)
482         {
483             StepRight(matcher.AddFullMatchedToResults, sequence[0], sequence[1]);
484         }
485         var last = sequence.Length - 2;
486         for (var i = 1; i < last; i++)
487         {
488             PartialStepRight(matcher.AddFullMatchedToResults, sequence[i],
489                             ↪ sequence[i + 1]);
490         }
491         if (sequence.Length >= 3)
492         {
493             StepLeft(matcher.AddFullMatchedToResults, sequence[sequence.Length - 2],
494                     ↪ sequence[sequence.Length - 1]);
495         }
496     }
497     return results;
498 });
499
500 public const int MaxSequenceFormatSize = 200;
501
502 [MethodImpl(MethodImplOptions.AggressiveInlining)]
503 public string FormatSequence(LinkIndex sequenceLink, params LinkIndex[] knownElements)
504     ↪ => FormatSequence(sequenceLink, (sb, x) => sb.Append(x), true, knownElements);
505
506 [MethodImpl(MethodImplOptions.AggressiveInlining)]
507 public string FormatSequence(LinkIndex sequenceLink, Action<StringBuilder, LinkIndex>
508     ↪ elementToString, bool insertComma, params LinkIndex[] knownElements) =>
509     ↪ Links.SyncRoot.ExecuteReadOperation(() => FormatSequence(Links.Unsync, sequenceLink,
510     ↪ elementToString, insertComma, knownElements));
511
512 [MethodImpl(MethodImplOptions.AggressiveInlining)]
513 private string FormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
514     ↪ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
515     ↪ LinkIndex[] knownElements)
516 {
517     var linksInSequence = new HashSet<ulong>(knownElements);
518     //var entered = new HashSet<ulong>();
519     var sb = new StringBuilder();
520     sb.Append('{');
521     if (links.Exists(sequenceLink))
522     {
523         StopableSequenceWalker.WalkRight(sequenceLink, links.GetSource, links.GetTarget,
524             x => linksInSequence.Contains(x) || links.IsPartialPoint(x), element => //
525             ↪ entered.AddAndReturnVoid, x => { }, entered.DoNotContains
526         {
527             if (insertComma && sb.Length > 1)
528             {
529                 sb.Append(',');
530             }
531             //if (entered.Contains(element))
532             //{
533             //    sb.Append('{');
534             //    elementToString(sb, element);
535             //    sb.Append('}');
536             //}
537             //else

```

```

530         elementToString(sb, element);
531         if (sb.Length < MaxSequenceFormatSize)
532         {
533             return true;
534         }
535         sb.Append(insertComma ? ", ..." : "...");
536         return false;
537     });
538 }
539 sb.Append('}');
540 return sb.ToString();
541 }
542
543 [MethodImpl(MethodImplOptions.AggressiveInlining)]
544 public string SafeFormatSequence(LinkIndex sequenceLink, params LinkIndex[]
    ↪ knownElements) => SafeFormatSequence(sequenceLink, (sb, x) => sb.Append(x), true,
    ↪ knownElements);
545
546 [MethodImpl(MethodImplOptions.AggressiveInlining)]
547 public string SafeFormatSequence(LinkIndex sequenceLink, Action<StringBuilder,
    ↪ LinkIndex> elementToString, bool insertComma, params LinkIndex[] knownElements) =>
    ↪ Links.SyncRoot.ExecuteReadOperation(() => SafeFormatSequence(Links.Unsync,
    ↪ sequenceLink, elementToString, insertComma, knownElements));
548
549 [MethodImpl(MethodImplOptions.AggressiveInlining)]
550 private string SafeFormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
    ↪ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
    ↪ LinkIndex[] knownElements)
551 {
552     var linksInSequence = new HashSet<ulong>(knownElements);
553     var entered = new HashSet<ulong>();
554     var sb = new StringBuilder();
555     sb.Append('{');
556     if (links.Exists(sequenceLink))
557     {
558         StopableSequenceWalker.WalkRight(sequenceLink, links.GetSource, links.GetTarget,
559             x => linksInSequence.Contains(x) || links.IsFullPoint(x),
    ↪ entered.AddAndReturnVoid, x => { }, entered.DoNotContains, element =>
560         {
561             if (insertComma && sb.Length > 1)
562             {
563                 sb.Append(',');
564             }
565             if (entered.Contains(element))
566             {
567                 sb.Append('{');
568                 elementToString(sb, element);
569                 sb.Append('}');
570             }
571             else
572             {
573                 elementToString(sb, element);
574             }
575             if (sb.Length < MaxSequenceFormatSize)
576             {
577                 return true;
578             }
579             sb.Append(insertComma ? ", ..." : "...");
580             return false;
581         });
582     }
583     sb.Append('}');
584     return sb.ToString();
585 }
586
587 [MethodImpl(MethodImplOptions.AggressiveInlining)]
588 public List<ulong> GetAllPartiallyMatchingSequences0(params ulong[] sequence)
589 {
590     return _sync.ExecuteReadOperation(() =>
591     {
592         if (sequence.Length > 0)
593         {
594             Links.EnsureLinkExists(sequence);
595             var results = new HashSet<ulong>();
596             for (var i = 0; i < sequence.Length; i++)
597             {
598                 AllUsagesCore(sequence[i], results);
599             }
600         }
601     });
602 }

```

```

600     var filteredResults = new List<ulong>();
601     var linksInSequence = new HashSet<ulong>(sequence);
602     foreach (var result in results)
603     {
604         var filterPosition = -1;
605         StopableSequenceWalker.WalkRight(result, Links.Unsync.GetSource,
        ↪ Links.Unsync.GetTarget,
        ↪ x => linksInSequence.Contains(x) || Links.Unsync.GetTarget(x) == x,
        ↪ x =>
        {
607             if (filterPosition == (sequence.Length - 1))
608             {
609                 return false;
610             }
611             if (filterPosition >= 0)
612             {
613                 if (x == sequence[filterPosition + 1])
614                 {
615                     filterPosition++;
616                 }
617                 else
618                 {
619                     return false;
620                 }
621             }
622             if (filterPosition < 0)
623             {
624                 if (x == sequence[0])
625                 {
626                     filterPosition = 0;
627                 }
628             }
629             return true;
630         });
631         if (filterPosition == (sequence.Length - 1))
632         {
633             filteredResults.Add(result);
634         }
635     }
636     return filteredResults;
637 }
638 return new List<ulong>();
639 });
640 }
641 }
642
643 [MethodImpl(MethodImplOptions.AggressiveInlining)]
644 public HashSet<ulong> GetAllPartiallyMatchingSequences1(params ulong[] sequence)
645 {
646     return _sync.ExecuteReadOperation(() =>
647     {
648         if (sequence.Length > 0)
649         {
650             Links.EnsureLinkExists(sequence);
651             var results = new HashSet<ulong>();
652             for (var i = 0; i < sequence.Length; i++)
653             {
654                 AllUsagesCore(sequence[i], results);
655             }
656             var filteredResults = new HashSet<ulong>();
657             var matcher = new Matcher(this, sequence, filteredResults, null);
658             matcher.AddAllPartialMatchedToResults(results);
659             return filteredResults;
660         }
661         return new HashSet<ulong>();
662     });
663 }
664
665 [MethodImpl(MethodImplOptions.AggressiveInlining)]
666 public bool GetAllPartiallyMatchingSequences2(Func<IList<LinkIndex>, LinkIndex> handler,
667 ↪ params ulong[] sequence)
668 {
669     return _sync.ExecuteReadOperation(() =>
670     {
671         if (sequence.Length > 0)
672         {
673             Links.EnsureLinkExists(sequence);
674
675             var results = new HashSet<ulong>();
676             var filteredResults = new HashSet<ulong>();

```



```

676         var matcher = new Matcher(this, sequence, filteredResults, handler);
677         for (var i = 0; i < sequence.Length; i++)
678         {
679             if (!AllUsagesCore1(sequence[i], results, matcher.HandlePartialMatched))
680             {
681                 return false;
682             }
683         }
684         return true;
685     }
686     return true;
687 });
688 }
689
690 //public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
691 //{
692 //    return Sync.ExecuteReadOperation(() =>
693 //    {
694 //        if (sequence.Length > 0)
695 //        {
696 //            _links.EnsureEachLinkIsAnyOrExists(sequence);
697 //
698 //            var firstResults = new HashSet<ulong>();
699 //            var lastResults = new HashSet<ulong>();
700 //
701 //            var first = sequence.First(x => x != LinksConstants.Any);
702 //            var last = sequence.Last(x => x != LinksConstants.Any);
703 //
704 //            AllUsagesCore(first, firstResults);
705 //            AllUsagesCore(last, lastResults);
706 //
707 //            firstResults.IntersectWith(lastResults);
708 //
709 //            //for (var i = 0; i < sequence.Length; i++)
710 //            //    AllUsagesCore(sequence[i], results);
711 //
712 //            var filteredResults = new HashSet<ulong>();
713 //            var matcher = new Matcher(this, sequence, filteredResults, null);
714 //            matcher.AddAllPartialMatchedToResults(firstResults);
715 //            return filteredResults;
716 //        }
717 //
718 //        return new HashSet<ulong>();
719 //    });
720 //}
721
722 [MethodImpl(MethodImplOptions.AggressiveInlining)]
723 public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
724 {
725     return _sync.ExecuteReadOperation(() =>
726     {
727         if (sequence.Length > 0)
728         {
729             ILinksExtensions.EnsureLinkIsAnyOrExists(Links, sequence);
730             var firstResults = new HashSet<ulong>();
731             var lastResults = new HashSet<ulong>();
732             var first = sequence.First(x => x != Constants.Any);
733             var last = sequence.Last(x => x != Constants.Any);
734             AllUsagesCore(first, firstResults);
735             AllUsagesCore(last, lastResults);
736             firstResults.IntersectWith(lastResults);
737             //for (var i = 0; i < sequence.Length; i++)
738             //    AllUsagesCore(sequence[i], results);
739             var filteredResults = new HashSet<ulong>();
740             var matcher = new Matcher(this, sequence, filteredResults, null);
741             matcher.AddAllPartialMatchedToResults(firstResults);
742             return filteredResults;
743         }
744         return new HashSet<ulong>();
745     });
746 }
747
748 [MethodImpl(MethodImplOptions.AggressiveInlining)]
749 public HashSet<ulong> GetAllPartiallyMatchingSequences4(HashSet<ulong> readAsElements,
750     ↪ IList<ulong> sequence)
751 {
752     return _sync.ExecuteReadOperation(() =>
753     {
754         if (sequence.Count > 0)

```

```

754     {
755         Links.EnsureLinkExists(sequence);
756         var results = new HashSet<LinkIndex>();
757         //var nextResults = new HashSet<ulong>();
758         //for (var i = 0; i < sequence.Length; i++)
759         //{
760             AllUsagesCore(sequence[i], nextResults);
761             if (results.IsNullOrEmpty())
762             {
763                 results = nextResults;
764                 nextResults = new HashSet<ulong>();
765             }
766             else
767             {
768                 results.IntersectWith(nextResults);
769                 nextResults.Clear();
770             }
771         //}
772         var collector1 = new AllUsagesCollector1(Links.Unsync, results);
773         collector1.Collect(Links.Unsync.GetLink(sequence[0]));
774         var next = new HashSet<ulong>();
775         for (var i = 1; i < sequence.Count; i++)
776         {
777             var collector = new AllUsagesCollector1(Links.Unsync, next);
778             collector.Collect(Links.Unsync.GetLink(sequence[i]));
779
780             results.IntersectWith(next);
781             next.Clear();
782         }
783         var filteredResults = new HashSet<ulong>();
784         var matcher = new Matcher(this, sequence, filteredResults, null,
785             ↪ readAsElements);
786         matcher.AddAllPartialMatchedToResultsAndReadAsElements(results.OrderBy(x =>
787             ↪ x)); // OrderBy is a Hack
788         return filteredResults;
789     }
790     });
791 }
792
793 // Does not work
794 //public HashSet<ulong> GetAllPartiallyMatchingSequences5(HashSet<ulong> readAsElements,
795 ↪ params ulong[] sequence)
796 //{
797     // var visited = new HashSet<ulong>();
798     // var results = new HashSet<ulong>();
799     // var matcher = new Matcher(this, sequence, visited, x => { results.Add(x); return
800     ↪ true; }, readAsElements);
801     // var last = sequence.Length - 1;
802     // for (var i = 0; i < last; i++)
803     // {
804         PartialStepRight(matcher.PartialMatch, sequence[i], sequence[i + 1]);
805     // }
806     // return results;
807 //}
808
809 [MethodImpl(MethodImplOptions.AggressiveInlining)]
810 public List<ulong> GetAllPartiallyMatchingSequences(params ulong[] sequence)
811 {
812     return _sync.ExecuteReadOperation(() =>
813     {
814         if (sequence.Length > 0)
815         {
816             Links.EnsureLinkExists(sequence);
817             //var firstElement = sequence[0];
818             //if (sequence.Length == 1)
819             //{
820                 //results.Add(firstElement);
821                 return results;
822             //}
823             //if (sequence.Length == 2)
824             //{
825                 //var doublet = _links.SearchCore(firstElement, sequence[1]);
826                 //if (doublet != Doublets.Links.Null)
827                 //    results.Add(doublet);
828                 return results;
829             //}
830             //var lastElement = sequence[sequence.Length - 1];

```

```

828 //Func<ulong, bool> handler = x =>
829 //{
830 //    if (StartsWith(x, firstElement) && EndsWith(x, lastElement))
831 //        results.Add(x);
832 //    return true;
833 //};
834 //if (sequence.Length >= 2)
835 //    StepRight(handler, sequence[0], sequence[1]);
836 //var last = sequence.Length - 2;
837 //for (var i = 1; i < last; i++)
838 //    PartialStepRight(handler, sequence[i], sequence[i + 1]);
839 //if (sequence.Length >= 3)
840 //    StepLeft(handler, sequence[sequence.Length - 2],
841 //        sequence[sequence.Length - 1]);
842 //if (sequence.Length == 1)
843 //    throw new NotImplementedException(); // all sequences, containing
844 //    this element?
845 //if (sequence.Length == 2)
846 //    {
847 //        var results = new List<ulong>();
848 //        PartialStepRight(results.Add, sequence[0], sequence[1]);
849 //        return results;
850 //    }
851 //var matches = new List<List<ulong>>();
852 //var last = sequence.Length - 1;
853 //for (var i = 0; i < last; i++)
854 //    {
855 //        var results = new List<ulong>();
856 //        //StepRight(results.Add, sequence[i], sequence[i + 1]);
857 //        PartialStepRight(results.Add, sequence[i], sequence[i + 1]);
858 //        if (results.Count > 0)
859 //            matches.Add(results);
860 //        else
861 //            return results;
862 //        if (matches.Count == 2)
863 //            {
864 //                var merged = new List<ulong>();
865 //                for (var j = 0; j < matches[0].Count; j++)
866 //                    for (var k = 0; k < matches[1].Count; k++)
867 //                        CloseInnerConnections(merged.Add, matches[0][j],
868 //                            matches[1][k]);
869 //                if (merged.Count > 0)
870 //                    matches = new List<List<ulong>> { merged };
871 //                else
872 //                    return new List<ulong>();
873 //            }
874 //    }
875 //if (matches.Count > 0)
876 //    {
877 //        var usages = new HashSet<ulong>();
878 //        for (int i = 0; i < sequence.Length; i++)
879 //            {
880 //                AllUsagesCore(sequence[i], usages);
881 //            }
882 //        //for (int i = 0; i < matches[0].Count; i++)
883 //        //    AllUsagesCore(matches[0][i], usages);
884 //        //usages.UnionWith(matches[0]);
885 //        return usages.ToList();
886 //    }
887 var firstLinkUsages = new HashSet<ulong>();
888 AllUsagesCore(sequence[0], firstLinkUsages);
889 firstLinkUsages.Add(sequence[0]);
890 //var previousMatchings = firstLinkUsages.ToList(); //new List<ulong>() {
891 //    sequence[0] }; // or all sequences, containing this element?
892 //return GetAllPartiallyMatchingSequencesCore(sequence, firstLinkUsages,
893 //    1).ToList();
894 var results = new HashSet<ulong>();
895 foreach (var match in GetAllPartiallyMatchingSequencesCore(sequence,
896 //    firstLinkUsages, 1))
897 {
898     AllUsagesCore(match, results);
899 }
900 return results.ToList();
901 }
902 return new List<ulong>();
903

```

```

898     });
899 }
900
901 /// <remarks>
902 /// TODO: Может потребоваться ограничение на уровень глубины рекурсии
903 /// </remarks>
904 [MethodImpl(MethodImplOptions.AggressiveInlining)]
905 public HashSet<ulong> AllUsages(ulong link)
906 {
907     return _sync.ExecuteReadOperation(() =>
908     {
909         var usages = new HashSet<ulong>();
910         AllUsagesCore(link, usages);
911         return usages;
912     });
913 }
914
915 // При сборе всех использований (последовательностей) можно сохранять обратный путь к
916 //   ↳ той связи с которой начинался поиск (STTTSSSTT),
917 // причём достаточно одного бита для хранения перехода влево или вправо
918 [MethodImpl(MethodImplOptions.AggressiveInlining)]
919 private void AllUsagesCore(ulong link, HashSet<ulong> usages)
920 {
921     bool handler(ulong doublet)
922     {
923         if (usages.Add(doublet))
924         {
925             AllUsagesCore(doublet, usages);
926         }
927         return true;
928     }
929     Links.Unsync.Each(link, Constants.Any, handler);
930     Links.Unsync.Each(Constants.Any, link, handler);
931 }
932
933 [MethodImpl(MethodImplOptions.AggressiveInlining)]
934 public HashSet<ulong> AllBottomUsages(ulong link)
935 {
936     return _sync.ExecuteReadOperation(() =>
937     {
938         var visits = new HashSet<ulong>();
939         var usages = new HashSet<ulong>();
940         AllBottomUsagesCore(link, visits, usages);
941         return usages;
942     });
943 }
944
945 [MethodImpl(MethodImplOptions.AggressiveInlining)]
946 private void AllBottomUsagesCore(ulong link, HashSet<ulong> visits, HashSet<ulong>
947   ↳ usages)
948 {
949     bool handler(ulong doublet)
950     {
951         if (visits.Add(doublet))
952         {
953             AllBottomUsagesCore(doublet, visits, usages);
954         }
955         return true;
956     }
957     if (Links.Unsync.Count(Constants.Any, link) == 0)
958     {
959         usages.Add(link);
960     }
961     else
962     {
963         Links.Unsync.Each(link, Constants.Any, handler);
964         Links.Unsync.Each(Constants.Any, link, handler);
965     }
966 }
967
968 [MethodImpl(MethodImplOptions.AggressiveInlining)]
969 public ulong CalculateTotalSymbolFrequencyCore(ulong symbol)
970 {
971     if (Options.UseSequenceMarker)
972     {
973         var counter = new TotalMarkedSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
974   ↳ Options.MarkedSequenceMatcher, symbol);
975         return counter.Count();
976     }
977 }

```

```

973     }
974     else
975     {
976         var counter = new TotalSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
977             ↪ symbol);
978         return counter.Count();
979     }
980 }
981 [MethodImpl(MethodImplOptions.AggressiveInlining)]
982 private bool AllUsagesCore1(ulong link, HashSet<ulong> usages, Func<IList<LinkIndex>,
983     ↪ LinkIndex> outerHandler)
984 {
985     bool handler(ulong doublet)
986     {
987         if (usages.Add(doublet))
988         {
989             if (outerHandler(new LinkAddress<LinkIndex>(doublet)) != Constants.Continue)
990             {
991                 return false;
992             }
993             if (!AllUsagesCore1(doublet, usages, outerHandler))
994             {
995                 return false;
996             }
997         }
998         return true;
999     }
1000     return Links.Unsync.Each(link, Constants.Any, handler)
1001         && Links.Unsync.Each(Constants.Any, link, handler);
1002 }
1003 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1004 public void CalculateAllUsages(ulong[] totals)
1005 {
1006     var calculator = new AllUsagesCalculator(Links, totals);
1007     calculator.Calculate();
1008 }
1009 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1010 public void CalculateAllUsages2(ulong[] totals)
1011 {
1012     var calculator = new AllUsagesCalculator2(Links, totals);
1013     calculator.Calculate();
1014 }
1015 }
1016 private class AllUsagesCalculator
1017 {
1018     private readonly SynchronizedLinks<ulong> _links;
1019     private readonly ulong[] _totals;
1020
1021     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1022     public AllUsagesCalculator(SynchronizedLinks<ulong> links, ulong[] totals)
1023     {
1024         _links = links;
1025         _totals = totals;
1026     }
1027
1028     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1029     public void Calculate() => _links.Each(_links.Constants.Any, _links.Constants.Any,
1030         ↪ CalculateCore);
1031
1032     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1033     private bool CalculateCore(ulong link)
1034     {
1035         if (_totals[link] == 0)
1036         {
1037             var total = 1UL;
1038             _totals[link] = total;
1039             var visitedChildren = new HashSet<ulong>();
1040             bool linkCalculator(ulong child)
1041             {
1042                 if (link != child && visitedChildren.Add(child))
1043                 {
1044                     total += _totals[child] == 0 ? 1 : _totals[child];
1045                 }
1046                 return true;
1047             }
1048             _links.Unsync.Each(link, _links.Constants.Any, linkCalculator);

```

```

1049         _links.Unsync.Each(_links.Constants.Any, link, linkCalculator);
1050         _totals[link] = total;
1051     }
1052     return true;
1053 }
1054 }
1055
1056 private class AllUsagesCalculator2
1057 {
1058     private readonly SynchronizedLinks<ulong> _links;
1059     private readonly ulong[] _totals;
1060
1061     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1062     public AllUsagesCalculator2(SynchronizedLinks<ulong> links, ulong[] totals)
1063     {
1064         _links = links;
1065         _totals = totals;
1066     }
1067
1068     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1069     public void Calculate() => _links.Each(_links.Constants.Any, _links.Constants.Any,
1070         ↪ CalculateCore);
1071
1072     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1073     private bool IsElement(ulong link)
1074     {
1075         // _linksInSequence.Contains(link) ||
1076         return _links.Unsync.GetTarget(link) == link || _links.Unsync.GetSource(link) ==
1077             ↪ link;
1078     }
1079
1080     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1081     private bool CalculateCore(ulong link)
1082     {
1083         // TODO: Проработать защиту от заикливания
1084         // Основано на SequenceWalker.WalkLeft
1085         Func<ulong, ulong> getSource = _links.Unsync.GetSource;
1086         Func<ulong, ulong> getTarget = _links.Unsync.GetTarget;
1087         Func<ulong, bool> isElement = IsElement;
1088         void visitLeaf(ulong parent)
1089         {
1090             if (link != parent)
1091             {
1092                 _totals[parent]++;
1093             }
1094         }
1095         void visitNode(ulong parent)
1096         {
1097             if (link != parent)
1098             {
1099                 _totals[parent]++;
1100             }
1101         }
1102         var stack = new Stack();
1103         var element = link;
1104         if (isElement(element))
1105         {
1106             visitLeaf(element);
1107         }
1108         else
1109         {
1110             while (true)
1111             {
1112                 if (isElement(element))
1113                 {
1114                     if (stack.Count == 0)
1115                     {
1116                         break;
1117                     }
1118                     element = stack.Pop();
1119                     var source = getSource(element);
1120                     var target = getTarget(element);
1121                     // Обработка элемента
1122                     if (isElement(target))
1123                     {
1124                         visitLeaf(target);
1125                     }
1126                     if (isElement(source))
1127                     {

```

```

1126         visitLeaf(source);
1127     }
1128     element = source;
1129 }
1130 else
1131 {
1132     stack.Push(element);
1133     visitNode(element);
1134     element = getTarget(element);
1135 }
1136 }
1137 }
1138 _totals[link]++;
1139 return true;
1140 }
1141 }
1142
1143 private class AllUsagesCollector
1144 {
1145     private readonly ILinks<ulong> _links;
1146     private readonly HashSet<ulong> _usages;
1147
1148     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1149     public AllUsagesCollector(ILinks<ulong> links, HashSet<ulong> usages)
1150     {
1151         _links = links;
1152         _usages = usages;
1153     }
1154
1155     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1156     public bool Collect(ulong link)
1157     {
1158         if (_usages.Add(link))
1159         {
1160             _links.Each(link, _links.Constants.Any, Collect);
1161             _links.Each(_links.Constants.Any, link, Collect);
1162         }
1163         return true;
1164     }
1165 }
1166
1167 private class AllUsagesCollector1
1168 {
1169     private readonly ILinks<ulong> _links;
1170     private readonly HashSet<ulong> _usages;
1171     private readonly ulong _continue;
1172
1173     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1174     public AllUsagesCollector1(ILinks<ulong> links, HashSet<ulong> usages)
1175     {
1176         _links = links;
1177         _usages = usages;
1178         _continue = _links.Constants.Continue;
1179     }
1180
1181     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1182     public ulong Collect(IList<ulong> link)
1183     {
1184         var linkIndex = _links.GetIndex(link);
1185         if (_usages.Add(linkIndex))
1186         {
1187             _links.Each(Collect, _links.Constants.Any, linkIndex);
1188         }
1189         return _continue;
1190     }
1191 }
1192
1193 private class AllUsagesCollector2
1194 {
1195     private readonly ILinks<ulong> _links;
1196     private readonly BitString _usages;
1197
1198     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1199     public AllUsagesCollector2(ILinks<ulong> links, BitString usages)
1200     {
1201         _links = links;
1202         _usages = usages;
1203     }
1204
1205     [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

1206     public bool Collect(ulong link)
1207     {
1208         if (_usages.Add((long)link))
1209         {
1210             _links.Each(link, _links.Constants.Any, Collect);
1211             _links.Each(_links.Constants.Any, link, Collect);
1212         }
1213         return true;
1214     }
1215 }
1216
1217 private class AllUsagesIntersectingCollector
1218 {
1219     private readonly SynchronizedLinks<ulong> _links;
1220     private readonly HashSet<ulong> _intersectWith;
1221     private readonly HashSet<ulong> _usages;
1222     private readonly HashSet<ulong> _enter;
1223
1224     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1225     public AllUsagesIntersectingCollector(SynchronizedLinks<ulong> links, HashSet<ulong>
        ↪ intersectWith, HashSet<ulong> usages)
1226     {
1227         _links = links;
1228         _intersectWith = intersectWith;
1229         _usages = usages;
1230         _enter = new HashSet<ulong>(); // защита от зацикливания
1231     }
1232
1233     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1234     public bool Collect(ulong link)
1235     {
1236         if (_enter.Add(link))
1237         {
1238             if (_intersectWith.Contains(link))
1239             {
1240                 _usages.Add(link);
1241             }
1242             _links.Unsync.Each(link, _links.Constants.Any, Collect);
1243             _links.Unsync.Each(_links.Constants.Any, link, Collect);
1244         }
1245         return true;
1246     }
1247 }
1248
1249 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1250 private void CloseInnerConnections(Action<IList<LinkIndex>> handler, ulong left, ulong
        ↪ right)
1251 {
1252     TryStepLeftUp(handler, left, right);
1253     TryStepRightUp(handler, right, left);
1254 }
1255
1256 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1257 private void AllCloseConnections(Action<IList<LinkIndex>> handler, ulong left, ulong
        ↪ right)
1258 {
1259     // Direct
1260     if (left == right)
1261     {
1262         handler(new LinkAddress<LinkIndex>(left));
1263     }
1264     var doublet = Links.Unsync.SearchOrDefault(left, right);
1265     if (doublet != Constants.Null)
1266     {
1267         handler(new LinkAddress<LinkIndex>(doublet));
1268     }
1269     // Inner
1270     CloseInnerConnections(handler, left, right);
1271     // Outer
1272     StepLeft(handler, left, right);
1273     StepRight(handler, left, right);
1274     PartialStepRight(handler, left, right);
1275     PartialStepLeft(handler, left, right);
1276 }
1277
1278 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1279 private HashSet<ulong> GetAllPartiallyMatchingSequencesCore(ulong[] sequence,
        ↪ HashSet<ulong> previousMatchings, long startAt)
1280 {

```



```

1281     if (startAt >= sequence.Length) // ?
1282     {
1283         return previousMatchings;
1284     }
1285     var secondLinkUsages = new HashSet<ulong>();
1286     AllUsagesCore(sequence[startAt], secondLinkUsages);
1287     secondLinkUsages.Add(sequence[startAt]);
1288     var matchings = new HashSet<ulong>();
1289     var filler = new SetFiller<LinkIndex, LinkIndex>(matchings, Constants.Continue);
1290     //for (var i = 0; i < previousMatchings.Count; i++)
1291     foreach (var secondLinkUsage in secondLinkUsages)
1292     {
1293         foreach (var previousMatching in previousMatchings)
1294         {
1295             //AllCloseConnections(matchings.AddAndReturnVoid, previousMatching,
1296             //    ↪ secondLinkUsage);
1297             StepRight(filler.AddFirstAndReturnConstant, previousMatching,
1298             //    ↪ secondLinkUsage);
1299             TryStepRightUp(filler.AddFirstAndReturnConstant, secondLinkUsage,
1300             //    ↪ previousMatching);
1301             //PartialStepRight(matchings.AddAndReturnVoid, secondLinkUsage,
1302             //    ↪ sequence[startAt]); // почему-то эта ошибочная запись приводит к
1303             //    ↪ желаемым результатам.
1304             PartialStepRight(filler.AddFirstAndReturnConstant, previousMatching,
1305             //    ↪ 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>
1317     ↪ links, params ulong[] sequence)
1318 {
1319     if (sequence == null)
1320     {
1321         return;
1322     }
1323     for (var i = 0; i < sequence.Length; i++)
1324     {
1325         if (sequence[i] != links.Constants.Any && sequence[i] != ZeroOrMany &&
1326             ↪ !links.Exists(sequence[i]))
1327         {
1328             throw new ArgumentLinkDoesNotExistsException<ulong>(sequence[i],
1329             ↪ $"patternSequence[{i}]");
1330         }
1331     }
1332 }
1333
1334 // Pattern Matching -> Key To Triggers
1335 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1336 public HashSet<ulong> MatchPattern(params ulong[] patternSequence)
1337 {
1338     return _sync.ExecuteReadOperation(() =>
1339     {
1340         patternSequence = Simplify(patternSequence);
1341         if (patternSequence.Length > 0)
1342         {
1343             EnsureEachLinkIsAnyOrZeroOrManyOrExists(Links, patternSequence);
1344             var uniqueSequenceElements = new HashSet<ulong>();
1345             for (var i = 0; i < patternSequence.Length; i++)
1346             {
1347                 if (patternSequence[i] != Constants.Any && patternSequence[i] !=
1348                     ↪ ZeroOrMany)
1349                 {
1350                     uniqueSequenceElements.Add(patternSequence[i]);
1351                 }
1352             }
1353             var results = new HashSet<ulong>();
1354             foreach (var uniqueSequenceElement in uniqueSequenceElements)
1355             {
1356                 AllUsagesCore(uniqueSequenceElement, results);
1357             }
1358         }
1359     });
1360 }

```

```

1348         var filteredResults = new HashSet<ulong>();
1349         var matcher = new PatternMatcher(this, patternSequence, filteredResults);
1350         matcher.AddAllPatternMatchedToResults(results);
1351         return filteredResults;
1352     }
1353     return new HashSet<ulong>();
1354 });
1355 }
1356
1357 // Найти все возможные связи между указанным списком связей.
1358 // Находит связи между всеми указанными связями в любом порядке.
1359 // TODO: решить что делать с повторами (когда одни и те же элементы встречаются
1360 // → несколько раз в последовательности)
1361 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1362 public HashSet<ulong> GetAllConnections(params ulong[] linksToConnect)
1363 {
1364     return _sync.ExecuteReadOperation(() =>
1365     {
1366         var results = new HashSet<ulong>();
1367         if (linksToConnect.Length > 0)
1368         {
1369             Links.EnsureLinkExists(linksToConnect);
1370             AllUsagesCore(linksToConnect[0], results);
1371             for (var i = 1; i < linksToConnect.Length; i++)
1372             {
1373                 var next = new HashSet<ulong>();
1374                 AllUsagesCore(linksToConnect[i], next);
1375                 results.IntersectWith(next);
1376             }
1377             return results;
1378         }
1379     });
1380 }
1381 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1382 public HashSet<ulong> GetAllConnections1(params ulong[] linksToConnect)
1383 {
1384     return _sync.ExecuteReadOperation(() =>
1385     {
1386         var results = new HashSet<ulong>();
1387         if (linksToConnect.Length > 0)
1388         {
1389             Links.EnsureLinkExists(linksToConnect);
1390             var collector1 = new AllUsagesCollector(Links.Unsync, results);
1391             collector1.Collect(linksToConnect[0]);
1392             var next = new HashSet<ulong>();
1393             for (var i = 1; i < linksToConnect.Length; i++)
1394             {
1395                 var collector = new AllUsagesCollector(Links.Unsync, next);
1396                 collector.Collect(linksToConnect[i]);
1397                 results.IntersectWith(next);
1398                 next.Clear();
1399             }
1400             return results;
1401         }
1402     });
1403 }
1404 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1405 public HashSet<ulong> GetAllConnections2(params ulong[] linksToConnect)
1406 {
1407     return _sync.ExecuteReadOperation(() =>
1408     {
1409         var results = new HashSet<ulong>();
1410         if (linksToConnect.Length > 0)
1411         {
1412             Links.EnsureLinkExists(linksToConnect);
1413             var collector1 = new AllUsagesCollector(Links, results);
1414             collector1.Collect(linksToConnect[0]);
1415             //AllUsagesCore(linksToConnect[0], results);
1416             for (var i = 1; i < linksToConnect.Length; i++)
1417             {
1418                 var next = new HashSet<ulong>();
1419                 var collector = new AllUsagesIntersectingCollector(Links, results, next);
1420                 collector.Collect(linksToConnect[i]);
1421                 //AllUsagesCore(linksToConnect[i], next);
1422                 //results.IntersectWith(next);
1423                 results = next;
1424             }
1425         }
1426     });
1427 }

```

```

1425     }
1426     }
1427     return results;
1428 });
1429 }
1430
1431 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1432 public List<ulong> GetAllConnections3(params ulong[] linksToConnect)
1433 {
1434     return _sync.ExecuteReadOperation(() =>
1435     {
1436         var results = new BitString((long)Links.Unsync.Count() + 1); // new
1437         ↪ BitArray((int)_links.Total + 1);
1438         if (linksToConnect.Length > 0)
1439         {
1440             Links.EnsureLinkExists(linksToConnect);
1441             var collector1 = new AllUsagesCollector2(Links.Unsync, results);
1442             collector1.Collect(linksToConnect[0]);
1443             for (var i = 1; i < linksToConnect.Length; i++)
1444             {
1445                 var next = new BitString((long)Links.Unsync.Count() + 1); //new
1446                 ↪ BitArray((int)_links.Total + 1);
1447                 var collector = new AllUsagesCollector2(Links.Unsync, next);
1448                 collector.Collect(linksToConnect[i]);
1449                 results = results.And(next);
1450             }
1451             return results.GetSetUInt64Indices();
1452         }
1453     });
1454 }
1455
1456 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1457 private static ulong[] Simplify(ulong[] sequence)
1458 {
1459     // Считаем новый размер последовательности
1460     long newLength = 0;
1461     var zeroOrManyStepped = false;
1462     for (var i = 0; i < sequence.Length; i++)
1463     {
1464         if (sequence[i] == ZeroOrMany)
1465         {
1466             if (zeroOrManyStepped)
1467             {
1468                 continue;
1469             }
1470             zeroOrManyStepped = true;
1471         }
1472         else
1473         {
1474             //if (zeroOrManyStepped) Is it efficient?
1475             zeroOrManyStepped = false;
1476         }
1477         newLength++;
1478     }
1479     // Строим новую последовательность
1480     zeroOrManyStepped = false;
1481     var newSequence = new ulong[newLength];
1482     long j = 0;
1483     for (var i = 0; i < sequence.Length; i++)
1484     {
1485         //var current = zeroOrManyStepped;
1486         //zeroOrManyStepped = patternSequence[i] == zeroOrMany;
1487         //if (current && zeroOrManyStepped)
1488         //    continue;
1489         //var newZeroOrManyStepped = patternSequence[i] == zeroOrMany;
1490         //if (zeroOrManyStepped && newZeroOrManyStepped)
1491         //    continue;
1492         //zeroOrManyStepped = newZeroOrManyStepped;
1493         if (sequence[i] == ZeroOrMany)
1494         {
1495             if (zeroOrManyStepped)
1496             {
1497                 continue;
1498             }
1499             zeroOrManyStepped = true;
1500         }
1501         else
1502         {
1503             //if (zeroOrManyStepped) Is it efficient?

```

```

1502         zeroOrManyStepped = false;
1503     }
1504     newSequence[j++] = sequence[i];
1505 }
1506 return newSequence;
1507 }
1508
1509 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1510 public static void TestSimplify()
1511 {
1512     var sequence = new ulong[] { ZeroOrMany, ZeroOrMany, 2, 3, 4, ZeroOrMany,
        ↪ ZeroOrMany, ZeroOrMany, 4, ZeroOrMany, ZeroOrMany, ZeroOrMany };
1513     var simplifiedSequence = Simplify(sequence);
1514 }
1515
1516 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1517 public List<ulong> GetSimilarSequences() => new List<ulong>();
1518
1519 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1520 public void Prediction()
1521 {
1522     //_links
1523     //_sequences
1524 }
1525
1526 #region From Triplets
1527
1528 //public static void DeleteSequence(Link sequence)
1529 //{
1530 //}
1531
1532 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1533 public List<ulong> CollectMatchingSequences(ulong[] links)
1534 {
1535     if (links.Length == 1)
1536     {
1537         throw new InvalidOperationException("Подпоследовательности с одним элементом не
        ↪ поддерживаются.");
1538     }
1539     var leftBound = 0;
1540     var rightBound = links.Length - 1;
1541     var left = links[leftBound++];
1542     var right = links[rightBound--];
1543     var results = new List<ulong>();
1544     CollectMatchingSequences(left, leftBound, links, right, rightBound, ref results);
1545     return results;
1546 }
1547
1548 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1549 private void CollectMatchingSequences(ulong leftLink, int leftBound, ulong[]
    ↪ middleLinks, ulong rightLink, int rightBound, ref List<ulong> results)
1550 {
1551     var leftLinkTotalReferers = Links.Unsync.Count(leftLink);
1552     var rightLinkTotalReferers = Links.Unsync.Count(rightLink);
1553     if (leftLinkTotalReferers <= rightLinkTotalReferers)
1554     {
1555         var nextLeftLink = middleLinks[leftBound];
1556         var elements = GetRightElements(leftLink, nextLeftLink);
1557         if (leftBound <= rightBound)
1558         {
1559             for (var i = elements.Length - 1; i >= 0; i--)
1560             {
1561                 var element = elements[i];
1562                 if (element != 0)
1563                 {
1564                     CollectMatchingSequences(element, leftBound + 1, middleLinks,
        ↪ rightLink, rightBound, ref results);
1565                 }
1566             }
1567         }
1568         else
1569         {
1570             for (var i = elements.Length - 1; i >= 0; i--)
1571             {
1572                 var element = elements[i];
1573                 if (element != 0)
1574                 {
1575                     results.Add(element);

```

```

1576     }
1577 }
1578 }
1579 }
1580 else
1581 {
1582     var nextRightLink = middleLinks[rightBound];
1583     var elements = GetLeftElements(rightLink, nextRightLink);
1584     if (leftBound <= rightBound)
1585     {
1586         for (var i = elements.Length - 1; i >= 0; i--)
1587         {
1588             var element = elements[i];
1589             if (element != 0)
1590             {
1591                 CollectMatchingSequences(leftLink, leftBound, middleLinks,
1592                                         ↪ elements[i], rightBound - 1, ref results);
1593             }
1594         }
1595     }
1596     else
1597     {
1598         for (var i = elements.Length - 1; i >= 0; i--)
1599         {
1600             var element = elements[i];
1601             if (element != 0)
1602             {
1603                 results.Add(element);
1604             }
1605         }
1606     }
1607 }
1608
1609 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1610 public ulong[] GetRightElements(ulong startLink, ulong rightLink)
1611 {
1612     var result = new ulong[5];
1613     TryStepRight(startLink, rightLink, result, 0);
1614     Links.Each(Constants.Any, startLink, couple =>
1615     {
1616         if (couple != startLink)
1617         {
1618             if (TryStepRight(couple, rightLink, result, 2))
1619             {
1620                 return false;
1621             }
1622         }
1623         return true;
1624     });
1625     if (Links.GetTarget(Links.GetTarget(startLink)) == rightLink)
1626     {
1627         result[4] = startLink;
1628     }
1629     return result;
1630 }
1631
1632 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1633 public bool TryStepRight(ulong startLink, ulong rightLink, ulong[] result, int offset)
1634 {
1635     var added = 0;
1636     Links.Each(startLink, Constants.Any, couple =>
1637     {
1638         if (couple != startLink)
1639         {
1640             var coupleTarget = Links.GetTarget(couple);
1641             if (coupleTarget == rightLink)
1642             {
1643                 result[offset] = couple;
1644                 if (++added == 2)
1645                 {
1646                     return false;
1647                 }
1648             }
1649             else if (Links.GetSource(coupleTarget) == rightLink) // coupleTarget.Linker
1650                 ↪ == Net.And &&
1651             {
1652                 result[offset + 1] = couple;

```

```

1652         if (++added == 2)
1653         {
1654             return false;
1655         }
1656     }
1657 }
1658     return true;
1659 });
1660     return added > 0;
1661 }
1662
1663 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1664 public ulong[] GetLeftElements(ulong startLink, ulong leftLink)
1665 {
1666     var result = new ulong[5];
1667     TryStepLeft(startLink, leftLink, result, 0);
1668     Links.Each(startLink, Constants.Any, couple =>
1669     {
1670         if (couple != startLink)
1671         {
1672             if (TryStepLeft(couple, leftLink, result, 2))
1673             {
1674                 return false;
1675             }
1676         }
1677         return true;
1678     });
1679     if (Links.GetSource(Links.GetSource(leftLink)) == startLink)
1680     {
1681         result[4] = leftLink;
1682     }
1683     return result;
1684 }
1685
1686 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1687 public bool TryStepLeft(ulong startLink, ulong leftLink, ulong[] result, int offset)
1688 {
1689     var added = 0;
1690     Links.Each(Constants.Any, startLink, couple =>
1691     {
1692         if (couple != startLink)
1693         {
1694             var coupleSource = Links.GetSource(couple);
1695             if (coupleSource == leftLink)
1696             {
1697                 result[offset] = couple;
1698                 if (++added == 2)
1699                 {
1700                     return false;
1701                 }
1702             }
1703             else if (Links.GetTarget(coupleSource) == leftLink) // coupleSource.Linker
1704                 ↪ == Net.And &&
1705             {
1706                 result[offset + 1] = couple;
1707                 if (++added == 2)
1708                 {
1709                     return false;
1710                 }
1711             }
1712         }
1713         return true;
1714     });
1715     return added > 0;
1716 }
1717 #endregion
1718
1719 #region Walkers
1720
1721 public class PatternMatcher : RightSequenceWalker<ulong>
1722 {
1723     private readonly Sequences _sequences;
1724     private readonly ulong[] _patternSequence;
1725     private readonly HashSet<LinkIndex> _linksInSequence;
1726     private readonly HashSet<LinkIndex> _results;
1727
1728     #region Pattern Match
1729     enum PatternBlockType
1730

```

```

1731     {
1732         Undefined,
1733         Gap,
1734         Elements
1735     }
1736
1737     struct PatternBlock
1738     {
1739         public PatternBlockType Type;
1740         public long Start;
1741         public long Stop;
1742     }
1743
1744     private readonly List<PatternBlock> _pattern;
1745     private int _patternPosition;
1746     private long _sequencePosition;
1747
1748     #endregion
1749
1750     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1751     public PatternMatcher(Sequences sequences, LinkIndex[] patternSequence,
1752         ↳ HashSet<LinkIndex> results)
1753         : base(sequences.Links.Unsync, new DefaultStack<ulong>())
1754     {
1755         _sequences = sequences;
1756         _patternSequence = patternSequence;
1757         _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
1758             ↳ _sequences.Constants.Any && x != ZeroOrMany));
1759         _results = results;
1760         _pattern = CreateDetailedPattern();
1761     }
1762
1763     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1764     protected override bool IsElement(ulong link) => _linksInSequence.Contains(link) ||
1765         ↳ base.IsElement(link);
1766
1767     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1768     public bool PatternMatch(LinkIndex sequenceToMatch)
1769     {
1770         _patternPosition = 0;
1771         _sequencePosition = 0;
1772         foreach (var part in Walk(sequenceToMatch))
1773         {
1774             if (!PatternMatchCore(part))
1775             {
1776                 break;
1777             }
1778         }
1779         return _patternPosition == _pattern.Count || (_patternPosition == _pattern.Count
1780             ↳ - 1 && _pattern[_patternPosition].Start == 0);
1781     }
1782
1783     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1784     private List<PatternBlock> CreateDetailedPattern()
1785     {
1786         var pattern = new List<PatternBlock>();
1787         var patternBlock = new PatternBlock();
1788         for (var i = 0; i < _patternSequence.Length; i++)
1789         {
1790             if (patternBlock.Type == PatternBlockType.Undefined)
1791             {
1792                 if (_patternSequence[i] == _sequences.Constants.Any)
1793                 {
1794                     patternBlock.Type = PatternBlockType.Gap;
1795                     patternBlock.Start = 1;
1796                     patternBlock.Stop = 1;
1797                 }
1798                 else if (_patternSequence[i] == ZeroOrMany)
1799                 {
1800                     patternBlock.Type = PatternBlockType.Gap;
1801                     patternBlock.Start = 0;
1802                     patternBlock.Stop = long.MaxValue;
1803                 }
1804                 else
1805                 {
1806                     patternBlock.Type = PatternBlockType.Elements;
1807                     patternBlock.Start = i;
1808                     patternBlock.Stop = i;
1809                 }
1810             }
1811         }
1812     }

```

```

1807     else if (patternBlock.Type == PatternBlockType.Elements)
1808     {
1809         if (_patternSequence[i] == _sequences.Constants.Any)
1810         {
1811             pattern.Add(patternBlock);
1812             patternBlock = new PatternBlock
1813             {
1814                 Type = PatternBlockType.Gap,
1815                 Start = 1,
1816                 Stop = 1
1817             };
1818         }
1819         else if (_patternSequence[i] == ZeroOrMany)
1820         {
1821             pattern.Add(patternBlock);
1822             patternBlock = new PatternBlock
1823             {
1824                 Type = PatternBlockType.Gap,
1825                 Start = 0,
1826                 Stop = long.MaxValue
1827             };
1828         }
1829         else
1830         {
1831             patternBlock.Stop = i;
1832         }
1833     }
1834     else // patternBlock.Type == PatternBlockType.Gap
1835     {
1836         if (_patternSequence[i] == _sequences.Constants.Any)
1837         {
1838             patternBlock.Start++;
1839             if (patternBlock.Stop < patternBlock.Start)
1840             {
1841                 patternBlock.Stop = patternBlock.Start;
1842             }
1843         }
1844         else if (_patternSequence[i] == ZeroOrMany)
1845         {
1846             patternBlock.Stop = long.MaxValue;
1847         }
1848         else
1849         {
1850             pattern.Add(patternBlock);
1851             patternBlock = new PatternBlock
1852             {
1853                 Type = PatternBlockType.Elements,
1854                 Start = i,
1855                 Stop = i
1856             };
1857         }
1858     }
1859 }
1860 if (patternBlock.Type != PatternBlockType.Undefined)
1861 {
1862     pattern.Add(patternBlock);
1863 }
1864 return pattern;
1865 }
1866
1867 // match: search for regexp anywhere in text
1868 //int match(char* regexp, char* text)
1869 //{
1870 //    do
1871 //    {
1872 //    } while (*text++ != '\0');
1873 //    return 0;
1874 //}
1875
1876 // matchhere: search for regexp at beginning of text
1877 //int matchhere(char* regexp, char* text)
1878 //{
1879 //    if (regexp[0] == '\0')
1880 //        return 1;
1881 //    if (regexp[1] == '*')
1882 //        return matchstar(regexp[0], regexp + 2, text);
1883 //    if (regexp[0] == '$' && regexp[1] == '\0')
1884 //        return *text == '\0';
1885 //    if (*text != '\0' && (regexp[0] == '.' || regexp[0] == *text))

```



```

1886 //         return matchhere(regexp + 1, text + 1);
1887 //     return 0;
1888 //}
1889
1890 // matchstar: search for c*regexp at beginning of text
1891 //int matchstar(int c, char* regexp, char* text)
1892 //{
1893 //    do
1894 //    {        /* a * matches zero or more instances */
1895 //        if (matchhere(regexp, text))
1896 //            return 1;
1897 //    } while (*text != '\0' && (*text++ == c || c == '.'));
1898 //    return 0;
1899 //}
1900
1901 //private void GetNextPatternElement(out LinkIndex element, out long mininumGap, out
1902 //    ↪ long maximumGap)
1903 //{
1904 //    mininumGap = 0;
1905 //    maximumGap = 0;
1906 //    element = 0;
1907 //    for (; _patternPosition < _patternSequence.Length; _patternPosition++)
1908 //    {
1909 //        if (_patternSequence[_patternPosition] == Doublets.Links.Null)
1910 //            mininumGap++;
1911 //        else if (_patternSequence[_patternPosition] == ZeroOrMany)
1912 //            maximumGap = long.MaxValue;
1913 //        else
1914 //            break;
1915 //    }
1916 //    if (maximumGap < mininumGap)
1917 //        maximumGap = mininumGap;
1918 //}
1919
1920 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1921 private bool PatternMatchCore(LinkIndex element)
1922 {
1923     if (_patternPosition >= _pattern.Count)
1924     {
1925         _patternPosition = -2;
1926         return false;
1927     }
1928     var currentPatternBlock = _pattern[_patternPosition];
1929     if (currentPatternBlock.Type == PatternBlockType.Gap)
1930     {
1931         //var currentMatchingBlockLength = (_sequencePosition -
1932         ↪ _lastMatchedBlockPosition);
1933         if (_sequencePosition < currentPatternBlock.Start)
1934         {
1935             _sequencePosition++;
1936             return true; // Двигаемся дальше
1937         }
1938         // Это последний блок
1939         if (_pattern.Count == _patternPosition + 1)
1940         {
1941             _patternPosition++;
1942             _sequencePosition = 0;
1943             return false; // Полное соответствие
1944         }
1945         else
1946         {
1947             if (_sequencePosition > currentPatternBlock.Stop)
1948             {
1949                 return false; // Соответствие невозможно
1950             }
1951             var nextPatternBlock = _pattern[_patternPosition + 1];
1952             if (_patternSequence[nextPatternBlock.Start] == element)
1953             {
1954                 if (nextPatternBlock.Start < nextPatternBlock.Stop)
1955                 {
1956                     _patternPosition++;
1957                     _sequencePosition = 1;
1958                 }
1959                 else
1960                 {
1961                     _patternPosition += 2;
1962                     _sequencePosition = 0;
1963                 }
1964             }
1965         }
1966     }

```

```

1963     }
1964 }
1965 }
1966 else // currentPatternBlock.Type == PatternBlockType.Elements
1967 {
1968     var patternElementPosition = currentPatternBlock.Start + _sequencePosition;
1969     if (_patternSequence[patternElementPosition] != element)
1970     {
1971         return false; // Соответствие невозможно
1972     }
1973     if (patternElementPosition == currentPatternBlock.Stop)
1974     {
1975         _patternPosition++;
1976         _sequencePosition = 0;
1977     }
1978     else
1979     {
1980         _sequencePosition++;
1981     }
1982 }
1983 return true;
1984 //if (_patternSequence[_patternPosition] != element)
1985 //    return false;
1986 //else
1987 //{
1988 //    _sequencePosition++;
1989 //    _patternPosition++;
1990 //    return true;
1991 //}
1992 ///////
1993 //if (_filterPosition == _patternSequence.Length)
1994 //{
1995 //    _filterPosition = -2; // Длиннее чем нужно
1996 //    return false;
1997 //}
1998 //if (element != _patternSequence[_filterPosition])
1999 //{
2000 //    _filterPosition = -1;
2001 //    return false; // Начинается иначе
2002 //}
2003 //_filterPosition++;
2004 //if (_filterPosition == (_patternSequence.Length - 1))
2005 //    return false;
2006 //if (_filterPosition >= 0)
2007 //{
2008 //    if (element == _patternSequence[_filterPosition + 1])
2009 //        _filterPosition++;
2010 //    else
2011 //        return false;
2012 //}
2013 //if (_filterPosition < 0)
2014 //{
2015 //    if (element == _patternSequence[0])
2016 //        _filterPosition = 0;
2017 //}
2018 }
2019
2020 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2021 public void AddAllPatternMatchedToResults(IEnumerable<ulong> sequencesToMatch)
2022 {
2023     foreach (var sequenceToMatch in sequencesToMatch)
2024     {
2025         if (PatternMatch(sequenceToMatch))
2026         {
2027             _results.Add(sequenceToMatch);
2028         }
2029     }
2030 }
2031 }
2032
2033 #endregion
2034 }
2035 }

```

1.151 ./csharp/Platform.Data.Doublets/Sequences/Sequences.cs

```

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

```

```

5 using Platform.Collections;
6 using Platform.Collections.Lists;
7 using Platform.Collections.Stacks;
8 using Platform.Threading.Synchronization;
9 using Platform.Data.Doublets.Sequences.Walkers;
10 using LinkIndex = System.UInt64;
11
12 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
13
14 namespace Platform.Data.Doublets.Sequences
15 {
16     /// <summary>
17     /// Представляет коллекцию последовательностей связей.
18     /// </summary>
19     /// <remarks>
20     /// Обязательно реализовать атомарность каждого публичного метода.
21     ///
22     /// TODO:
23     ///
24     /// !!! Повышение вероятности повторного использования групп (подпоследовательностей),
25     /// через естественную группировку по unicode типам, все whitespace вместе, все символы
26     /// ↪ вместе, все числа вместе и т.п.
27     /// + использовать ровно сбалансированный вариант, чтобы уменьшать вложенность (глубину
28     /// ↪ графа)
29     ///
30     /// х*у - найти все связи между, в последовательностях любой формы, если не стоит
31     /// ↪ ограничитель на то, что является последовательностью, а что нет,
32     /// то находятся любые структуры связей, которые содержат эти элементы именно в таком
33     /// ↪ порядке.
34     ///
35     /// Рост последовательности слева и справа.
36     /// Поиск со звёздочкой.
37     /// URL, PURL - реестр используемых во вне ссылок на ресурсы,
38     /// так же проблема может быть решена при реализации дистанционных триггеров.
39     /// Нужны ли уникальные указатели вообще?
40     /// Что если обращение к информации будет происходить через содержимое всегда?
41     ///
42     /// Писать тесты.
43     ///
44     ///
45     /// Можно убрать зависимость от конкретной реализации Links,
46     /// на зависимость от абстрактного элемента, который может быть представлен несколькими
47     /// ↪ способами.
48     ///
49     /// Можно ли как-то сделать один общий интерфейс
50     ///
51     ///
52     /// Блокчейн и/или гит для распределённой записи транзакций.
53     ///
54     /// </remarks>
55     public partial class Sequences : ILinks<LinkIndex> // IList<string>, IList<LinkIndex[]>
56     ↪ (после завершения реализации Sequences)
57     {
58         /// <summary>Возвращает значение LinkIndex, обозначающее любое количество
59         ↪ связей.</summary>
60         public const LinkIndex ZeroOrMany = LinkIndex.MaxValue;
61
62         public SequencesOptions<LinkIndex> Options { get; }
63         public SynchronizedLinks<LinkIndex> Links { get; }
64         private readonly ISynchronization _sync;
65
66         public LinksConstants<LinkIndex> Constants { get; }
67
68         [MethodImpl(MethodImplOptions.AggressiveInlining)]
69         public Sequences(SynchronizedLinks<LinkIndex> links, SequencesOptions<LinkIndex> options)
70         {
71             Links = links;
72             _sync = links.SyncRoot;
73             Options = options;
74             Options.ValidateOptions();
75             Options.InitOptions(Links);
76             Constants = links.Constants;
77         }
78
79         [MethodImpl(MethodImplOptions.AggressiveInlining)]
80         public Sequences(SynchronizedLinks<LinkIndex> links) : this(links, new
81         ↪ SequencesOptions<LinkIndex>()) { }
82
83         [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(ICollection<LinkIndex> restrictions)
120 {
121     if (restrictions.IsNullOrEmpty())
122     {
123         return Links.Count(Constants.Any, Options.SequenceMarkerLink, Constants.Any);
124     }
125     if (restrictions.Count == 1) // Первая связь это адрес
126     {
127         var sequenceIndex = restrictions[0];
128         if (sequenceIndex == Constants.Null)
129         {
130             return 0;
131         }
132         if (sequenceIndex == Constants.Any)
133         {
134             return Count(null);
135         }
136         if (Options.UseSequenceMarker)
137         {
138             return Links.Count(Constants.Any, Options.SequenceMarkerLink, sequenceIndex);
139         }
140         return Links.Exists(sequenceIndex) ? 1UL : 0;
141     }
142     throw new NotImplementedException();
143 }
144
145 [MethodImpl(MethodImplOptions.AggressiveInlining)]
146 private LinkIndex CountUsages(params LinkIndex[] restrictions)
147 {
148     if (restrictions.Length == 0)
149     {
150         return 0;
151     }
152     if (restrictions.Length == 1) // Первая связь это адрес
153     {
154         if (restrictions[0] == Constants.Null)

```

```

155     {
156         return 0;
157     }
158     var any = Constants.Any;
159     if (Options.UseSequenceMarker)
160     {
161         var elementsLink = GetSequenceElements(restrictions[0]);
162         var sequenceLink = GetSequenceByElements(elementsLink);
163         if (sequenceLink != Constants.Null)
164         {
165             return Links.Count(any, sequenceLink) + Links.Count(any, elementsLink) -
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 #endregion
224
225 #region Each
226
227 [MethodImpl(MethodImplOptions.AggressiveInlining)]
228 public List<LinkIndex> Each(ICollection<LinkIndex> sequence)
229 {
230     var results = new List<LinkIndex>();
231     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]) !=
309             ↪ Constants.Continue)
310         {
311             return Constants.Break;
312         }
313     }
314     if (values.Count >= 3)
315     {
316         if (StepLeft(innerHandler, values[values.Count - 2], values[values.Count - 1])
317             ↪ != Constants.Continue)
318         {
319             return Constants.Break;
320         }
321     }
322     return Constants.Continue;
323 }
324 [MethodImpl(MethodImplOptions.AggressiveInlining)]
325 private LinkIndex PartialStepRight(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
326     ↪ left, LinkIndex right)
327 {
328     return Links.Unsync.Each(doublet =>
329     {
330         var doubletIndex = doublet[Constants.IndexPart];
331         if (StepRight(handler, doubletIndex, right) != Constants.Continue)
332         {
333             return Constants.Break;
334         }
335         if (left != doubletIndex)
336         {
337             return PartialStepRight(handler, doubletIndex, right);
338         }
339         return Constants.Continue;
340     }, new Link<LinkIndex>(Constants.Any, Constants.Any, left));
341 }
342 [MethodImpl(MethodImplOptions.AggressiveInlining)]
343 private LinkIndex StepRight(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex left,
344     ↪ LinkIndex right) => Links.Unsync.Each(rightStep => TryStepRightUp(handler, right,
345     ↪ rightStep[Constants.IndexPart]), new Link<LinkIndex>(Constants.Any, left,
346     ↪ Constants.Any));
347 [MethodImpl(MethodImplOptions.AggressiveInlining)]
348 private LinkIndex TryStepRightUp(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
349     ↪ right, LinkIndex stepFrom)
350 {
351     var upStep = stepFrom;
352     var firstSource = Links.Unsync.GetTarget(upStep);
353     while (firstSource != right && firstSource != upStep)
354     {
355         upStep = firstSource;
356         firstSource = Links.Unsync.GetSource(upStep);
357     }
358     if (firstSource == right)
359     {
360         return handler(new LinkAddress<LinkIndex>(stepFrom));
361     }
362     return Constants.Continue;
363 }
364 [MethodImpl(MethodImplOptions.AggressiveInlining)]
365 private LinkIndex StepLeft(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex left,
366     ↪ LinkIndex right) => Links.Unsync.Each(leftStep => TryStepLeftUp(handler, left,
367     ↪ leftStep[Constants.IndexPart]), new Link<LinkIndex>(Constants.Any, Constants.Any,
368     ↪ right));
369 [MethodImpl(MethodImplOptions.AggressiveInlining)]
370 private LinkIndex TryStepLeftUp(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
371     ↪ left, LinkIndex stepFrom)
372 {
373     var upStep = stepFrom;
374     var firstTarget = Links.Unsync.GetSource(upStep);
375     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);

```



```

446     if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
447     {
448         if (sequenceLink != Constants.Null)
449         {
450             Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
451         }
452         Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
453     }
454     ClearGarbage(sequenceElementsContents.Source);
455     ClearGarbage(sequenceElementsContents.Target);
456 }
457 else
458 {
459     if (Options.UseSequenceMarker)
460     {
461         var sequenceElements = GetSequenceElements(sequence);
462         var sequenceLink = GetSequenceByElements(sequenceElements);
463         var newSequenceElements = GetSequenceElements(newSequence);
464         var newSequenceLink = GetSequenceByElements(newSequenceElements);
465         if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
466         {
467             if (sequenceLink != Constants.Null)
468             {
469                 Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
470             }
471             Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
472         }
473     }
474     else
475     {
476         if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
477         {
478             Links.Unsync.MergeAndDelete(sequence, newSequence);
479         }
480     }
481 }
482 }
483
484 #endregion
485
486 #region Delete
487
488 [MethodImpl(MethodImplOptions.AggressiveInlining)]
489 public void Delete(IList<LinkIndex> restrictions)
490 {
491     _sync.ExecuteWriteOperation(() =>
492     {
493         var sequence = restrictions.SkipFirst();
494         // TODO: Check all options only ones before loop execution
495         foreach (var linkToDelete in Each(sequence))
496         {
497             DeleteOneCore(linkToDelete);
498         }
499     });
500 }
501
502 [MethodImpl(MethodImplOptions.AggressiveInlining)]
503 private void DeleteOneCore(LinkIndex link)
504 {
505     if (Options.UseGarbageCollection)
506     {
507         var sequenceElements = GetSequenceElements(link);
508         var sequenceElementsContents = new Link<ulong>(Links.GetLink(sequenceElements));
509         var sequenceLink = GetSequenceByElements(sequenceElements);
510         if (Options.UseCascadeDelete || CountUsages(link) == 0)
511         {
512             if (sequenceLink != Constants.Null)
513             {
514                 Links.Unsync.Delete(sequenceLink);
515             }
516             Links.Unsync.Delete(link);
517         }
518         ClearGarbage(sequenceElementsContents.Source);
519         ClearGarbage(sequenceElementsContents.Target);
520     }
521     else
522     {
523         if (Options.UseSequenceMarker)

```

```

524     {
525         var sequenceElements = GetSequenceElements(link);
526         var sequenceLink = GetSequenceByElements(sequenceElements);
527         if (Options.UseCascadeDelete || CountUsages(link) == 0)
528         {
529             if (sequenceLink != Constants.Null)
530             {
531                 Links.Unsync.Delete(sequenceLink);
532             }
533             Links.Unsync.Delete(link);
534         }
535     }
536     else
537     {
538         if (Options.UseCascadeDelete || CountUsages(link) == 0)
539         {
540             Links.Unsync.Delete(link);
541         }
542     }
543 }
544 }
545
546 #endregion
547
548 #region Compactification
549
550 [MethodImpl(MethodImplOptions.AggressiveInlining)]
551 public void CompactAll()
552 {
553     _sync.ExecuteWriteOperation(() =>
554     {
555         var sequences = Each((LinkAddress<LinkIndex>)Constants.Any);
556         for (int i = 0; i < sequences.Count; i++)
557         {
558             var sequence = this.ToList(sequences[i]);
559             Compact(sequence.ShiftRight());
560         }
561     });
562 }
563
564 /// <remarks>
565 /// bestVariant можно выбирать по максимальному числу использований,
566 /// но 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,
587     ↪ sequence);
588
589 #endregion
590
591 #region Garbage Collection
592
593 /// <remarks>
594 /// TODO: Добавить дополнительный обработчик / событие CanBeDeleted которое можно
595 ↪ определить извне или в унаследованном классе
596 /// </remarks>
597 [MethodImpl(MethodImplOptions.AggressiveInlining)]
598 private bool IsGarbage(LinkIndex link) => link != Options.SequenceMarkerLink &&
599     ↪ !Links.Unsync.IsPartialPoint(link) && Links.Count(Constants.Any, link) == 0;
600
601 [MethodImpl(MethodImplOptions.AggressiveInlining)]
602 private void ClearGarbage(LinkIndex link)

```

```

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,
643         ↪ HashSet<LinkIndex> results, Func<IList<LinkIndex>, LinkIndex> stopableHandler,
644         ↪ HashSet<LinkIndex> readAsElements = null)
645         : base(sequences.Links.Unsync, new DefaultStack<LinkIndex>())
646     {
647         _sequences = sequences;
648         _patternSequence = patternSequence;
649         _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
650             ↪ _links.Constants.Any && x != ZeroOrMany));
651         _results = results;
652         _stopableHandler = stopableHandler;
653         _readAsElements = readAsElements;
654     }
655
656     [MethodImpl(MethodImplOptions.AggressiveInlining)]
657     protected override bool IsElement(LinkIndex link) => base.IsElement(link) ||
658         ↪ (_readAsElements != null && _readAsElements.Contains(link)) ||
659         ↪ _linksInSequence.Contains(link);
660
661     [MethodImpl(MethodImplOptions.AggressiveInlining)]
662     public bool FullMatch(LinkIndex sequenceToMatch)
663     {
664         _filterPosition = 0;
665         foreach (var part in Walk(sequenceToMatch))
666         {
667             if (!FullMatchCore(part))
668             {
669                 break;
670             }
671         }
672         return _filterPosition == _patternSequence.Count;
673     }
674
675     [MethodImpl(MethodImplOptions.AggressiveInlining)]
676     private bool FullMatchCore(LinkIndex element)
677     {
678         if (_filterPosition == _patternSequence.Count)
679         {

```

```

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

```

```

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

```

1.152 ./csharp/Platform.Data.Doublets/Sequences/SequencesExtensions.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Collections.Lists;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Sequences
8  {
9      public static class SequencesExtensions
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public static TLink Create<TLink>(this ICollection<TLink> sequences, ICollection<TLink>
13         ↪ groupedSequence)
14     {

```

```

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] :
19             ↪ sequences.Create(part.ShiftRight());
20     }
21     return sequences.Create(finalSequence.ShiftRight());
22 }
23 [MethodImpl(MethodImplOptions.AggressiveInlining)]
24 public static IList<TLink> ToList<TLink>(this ILinks<TLink> sequences, TLink sequence)
25 {
26     var list = new List<TLink>();
27     var filler = new ListFiller<TLink, TLink>(list, sequences.Constants.Break);
28     sequences.Each(filler.AddSkipFirstAndReturnConstant, new
29         ↪ LinkAddress<TLink>(sequence));
30     return list;
31 }
32 }

```

1.153 ./csharp/Platform.Data.Doublets/Sequences/SequencesOptions.cs

```

1  using System;
2  using System.Collections.Generic;
3  using Platform.Interfaces;
4  using Platform.Collections.Stacks;
5  using Platform.Converters;
6  using Platform.Data.Doublets.Sequences.Frequencies.Cache;
7  using Platform.Data.Doublets.Sequences.Frequencies.Counters;
8  using Platform.Data.Doublets.Sequences.Converters;
9  using Platform.Data.Doublets.Sequences.Walkers;
10 using Platform.Data.Doublets.Sequences.Indexes;
11 using Platform.Data.Doublets.Sequences.CriterionMatchers;
12 using System.Runtime.CompilerServices;
13
14 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
15
16 namespace Platform.Data.Doublets.Sequences
17 {
18     public class SequencesOptions<TLink> // TODO: To use type parameter <TLink> the
19         ↪ ILinks<TLink> must contain GetConstants function.
20     {
21         private static readonly EqualityComparer<TLink> _equalityComparer =
22             ↪ EqualityComparer<TLink>.Default;
23
24         public TLink SequenceMarkerLink
25         {
26             [MethodImpl(MethodImplOptions.AggressiveInlining)]
27             get;
28             [MethodImpl(MethodImplOptions.AggressiveInlining)]
29             set;
30         }
31
32         public bool UseCascadeUpdate
33         {
34             [MethodImpl(MethodImplOptions.AggressiveInlining)]
35             get;
36             [MethodImpl(MethodImplOptions.AggressiveInlining)]
37             set;
38         }
39
40         public bool UseCascadeDelete
41         {
42             [MethodImpl(MethodImplOptions.AggressiveInlining)]
43             get;
44             [MethodImpl(MethodImplOptions.AggressiveInlining)]
45             set;
46         }
47
48         public bool UseIndex
49         {
50             [MethodImpl(MethodImplOptions.AggressiveInlining)]
51             get;
52             [MethodImpl(MethodImplOptions.AggressiveInlining)]
53             set;
54         }
55     } // TODO: Update Index on sequence update/delete.
56
57     public bool UseSequenceMarker
58     {
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         get;
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         set;
63     }
64 }

```

```

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)]
99         set;
100     }
101
102     public IConverter<IList<TLink>, TLink> LinksToSequenceConverter
103     {
104         [MethodImpl(MethodImplOptions.AggressiveInlining)]
105         get;
106         [MethodImpl(MethodImplOptions.AggressiveInlining)]
107         set;
108     }
109
110     public ISequenceIndex<TLink> Index
111     {
112         [MethodImpl(MethodImplOptions.AggressiveInlining)]
113         get;
114         [MethodImpl(MethodImplOptions.AggressiveInlining)]
115         set;
116     }
117
118     public ISequenceWalker<TLink> Walker
119     {
120         [MethodImpl(MethodImplOptions.AggressiveInlining)]
121         get;
122         [MethodImpl(MethodImplOptions.AggressiveInlining)]
123         set;
124     }
125
126     public bool ReadFullSequence
127     {
128         [MethodImpl(MethodImplOptions.AggressiveInlining)]
129         get;
130         [MethodImpl(MethodImplOptions.AggressiveInlining)]
131         set;
132     }
133
134     // TODO: Реализовать компактификацию при чтении
135     //public bool EnforceSingleSequenceVersionOnRead { get; set; }
136     //public bool UseRequestMarker { get; set; }
137     //public bool StoreRequestResults { get; set; }

```

```

138 [MethodImpl(MethodImplOptions.AggressiveInlining)]
139 public void InitOptions(ISynchronizedLinks<TLink> links)
140 {
141     if (UseSequenceMarker)
142     {
143         if (_equalityComparer.Equals(SequenceMarkerLink, links.Constants.Null))
144         {
145             SequenceMarkerLink = links.CreatePoint();
146         }
147         else
148         {
149             if (!links.Exists(SequenceMarkerLink))
150             {
151                 var link = links.CreatePoint();
152                 if (!_equalityComparer.Equals(link, SequenceMarkerLink))
153                 {
154                     throw new InvalidOperationException("Cannot recreate sequence marker
155                     ↪ link.");
156                 }
157             }
158         }
159         if (MarkedSequenceMatcher == null)
160         {
161             MarkedSequenceMatcher = new MarkedSequenceCriterionMatcher<TLink>(links,
162             ↪ SequenceMarkerLink);
163         }
164         var balancedVariantConverter = new BalancedVariantConverter<TLink>(links);
165         if (UseCompression)
166         {
167             if (LinksToSequenceConverter == null)
168             {
169                 ICounter<TLink, TLink> totalSequenceSymbolFrequencyCounter;
170                 if (UseSequenceMarker)
171                 {
172                     totalSequenceSymbolFrequencyCounter = new
173                     ↪ TotalMarkedSequenceSymbolFrequencyCounter<TLink>(links,
174                     ↪ MarkedSequenceMatcher);
175                 }
176                 else
177                 {
178                     totalSequenceSymbolFrequencyCounter = new
179                     ↪ TotalSequenceSymbolFrequencyCounter<TLink>(links);
180                 }
181                 var doubletFrequenciesCache = new LinkFrequenciesCache<TLink>(links,
182                 ↪ totalSequenceSymbolFrequencyCounter);
183                 var compressingConverter = new CompressingConverter<TLink>(links,
184                 ↪ balancedVariantConverter, doubletFrequenciesCache);
185                 LinksToSequenceConverter = compressingConverter;
186             }
187         }
188         else
189         {
190             if (LinksToSequenceConverter == null)
191             {
192                 LinksToSequenceConverter = balancedVariantConverter;
193             }
194         }
195         if (UseIndex && Index == null)
196         {
197             Index = new SequenceIndex<TLink>(links);
198         }
199         if (Walker == null)
200         {
201             Walker = new RightSequenceWalker<TLink>(links, new DefaultStack<TLink>());
202         }
203     }
204 }
205
206 [MethodImpl(MethodImplOptions.AggressiveInlining)]
207 public void ValidateOptions()
208 {
209     if (UseGarbageCollection && !UseSequenceMarker)
210     {
211         throw new NotSupportedException("To use garbage collection UseSequenceMarker
212         ↪ option must be on.");
213     }
214 }

```



```
208     }
209 }
```

1.154 ./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 }
```

1.155 ./csharp/Platform.Data.Doublets/Sequences/Walkers/LeftSequenceWalker.cs

```
1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4 using Platform.Collections.Stacks;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Sequences.Walkers
9 {
10     public class LeftSequenceWalker<TLink> : SequenceWalkerBase<TLink>
11     {
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public LeftSequenceWalker(ILinks<TLink> links, IStack<TLink> stack, Func<TLink, bool>
14             isElement) : base(links, stack, isElement) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public LeftSequenceWalker(ILinks<TLink> links, IStack<TLink> stack) : base(links, stack,
18             links.IsPartialPoint) { }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         protected override TLink GetNextElementAfterPop(TLink element) =>
22             _links.GetSource(element);
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected override TLink GetNextElementAfterPush(TLink element) =>
26             _links.GetTarget(element);
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         protected override IEnumerable<TLink> WalkContents(TLink element)
30         {
31             var links = _links;
32             var parts = links.GetLink(element);
33             var start = links.Constants.SourcePart;
34             for (var i = parts.Count - 1; i >= start; i--)
35             {
36                 var part = parts[i];
37                 if (IsElement(part))
38                 {
39                     yield return part;
40                 }
41             }
42         }
43     }
44 }
```

1.156 ./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                 {
57                     continue;
58                 }
59                 var doubletOffset = i * 2;
60                 if (_isElement(candidate))
61                 {
62                     nextArray[doubletOffset] = candidate;
63                 }
64                 else
65                 {
66                     var links = _links;
67                     var link = links.GetLink(candidate);
68                     var linkSource = links.GetSource(link);
69                     var linkTarget = links.GetTarget(link);
70                     nextArray[doubletOffset] = linkSource;
71                     nextArray[doubletOffset + 1] = linkTarget;
72                     if (!hasElements)
73                     {
74                         hasElements = !(_isElement(linkSource) && _isElement(linkTarget));
75                     }
76                 }
77             }
78             #if USEARRAYPOOL
79                 if (array.Length > 1)
80                 {
81                     ArrayPool.Free(array);
82                 }
83             #endif
84             array = nextArray;
85         }
86         while (hasElements);
87         var filledElementsCount = CountFilledElements(array);
88         if (filledElementsCount == array.Length)
89         {
90             return array;
91         }
92         else
93         {
94             return CopyFilledElements(array, filledElementsCount);
95         }
96     }
97 }

```

```

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 }

```

1.157 ./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 }

```

38 }

1.158 ./csharp/Platform.Data.Doublets/Sequences/Walkers/SequenceWalkerBase.cs

```
1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4 using Platform.Collections.Stacks;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Sequences.Walkers
9 {
10     public abstract class SequenceWalkerBase<TLink> : LinksOperatorBase<TLink>,
11         ↳ ISequenceWalker<TLink>
12     {
13         private readonly IStack<TLink> _stack;
14         private readonly Func<TLink, bool> _isElement;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected SequenceWalkerBase(ILinks<TLink> links, IStack<TLink> stack, Func<TLink, bool>
18             ↳ isElement) : base(links)
19         {
20             _stack = stack;
21             _isElement = isElement;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         protected SequenceWalkerBase(ILinks<TLink> links, IStack<TLink> stack) : this(links,
26             ↳ stack, links.IsPartialPoint) { }
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public IEnumerable<TLink> Walk(TLink sequence)
30         {
31             _stack.Clear();
32             var element = sequence;
33             if (IsElement(element))
34             {
35                 yield return element;
36             }
37             else
38             {
39                 while (true)
40                 {
41                     if (IsElement(element))
42                     {
43                         if (_stack.IsEmpty)
44                         {
45                             break;
46                         }
47                         element = _stack.Pop();
48                         foreach (var output in WalkContents(element))
49                         {
50                             yield return output;
51                         }
52                         element = GetNextElementAfterPop(element);
53                     }
54                     else
55                     {
56                         _stack.Push(element);
57                         element = GetNextElementAfterPush(element);
58                     }
59                 }
60             }
61         }
62
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         protected virtual bool IsElement(TLink elementLink) => _isElement(elementLink);
65
66         [MethodImpl(MethodImplOptions.AggressiveInlining)]
67         protected abstract TLink GetNextElementAfterPop(TLink element);
68
69         [MethodImpl(MethodImplOptions.AggressiveInlining)]
70         protected abstract TLink GetNextElementAfterPush(TLink element);
71
72         [MethodImpl(MethodImplOptions.AggressiveInlining)]
73         protected abstract IEnumerable<TLink> WalkContents(TLink element);
74     }
75 }
```

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

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Collections.Stacks;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Stacks
8 {
9     public class Stack<TLink> : LinksOperatorBase<TLink>, IStack<TLink>
10    {
11        private static readonly EqualityComparer<TLink> _equalityComparer =
12            ⇨ EqualityComparer<TLink>.Default;
13
14        private readonly TLink _stack;
15
16        public bool IsEmpty
17        {
18            [MethodImpl(MethodImplOptions.AggressiveInlining)]
19            get => _equalityComparer.Equals(Peek(), _stack);
20        }
21
22        [MethodImpl(MethodImplOptions.AggressiveInlining)]
23        public Stack(ILinks<TLink> links, TLink stack) : base(links) => _stack = stack;
24
25        [MethodImpl(MethodImplOptions.AggressiveInlining)]
26        private TLink GetStackMarker() => _links.GetSource(_stack);
27
28        [MethodImpl(MethodImplOptions.AggressiveInlining)]
29        private TLink GetTop() => _links.GetTarget(_stack);
30
31        [MethodImpl(MethodImplOptions.AggressiveInlining)]
32        public TLink Peek() => _links.GetTarget(GetTop());
33
34        [MethodImpl(MethodImplOptions.AggressiveInlining)]
35        public TLink Pop()
36        {
37            var element = Peek();
38            if (!_equalityComparer.Equals(element, _stack))
39            {
40                var top = GetTop();
41                var previousTop = _links.GetSource(top);
42                _links.Update(_stack, GetStackMarker(), previousTop);
43                _links.Delete(top);
44            }
45            return element;
46        }
47
48        [MethodImpl(MethodImplOptions.AggressiveInlining)]
49        public void Push(TLink element) => _links.Update(_stack, GetStackMarker(),
50            ⇨ _links.GetOrCreate(GetTop(), element));
51    }
52 }
```

1.160 ./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 }
```

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

```
1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4 using Platform.Data.Doublets;
5 using Platform.Threading.Synchronization;
6
```

```

7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublets
10 {
11     /// <remarks>
12     /// TODO: Autogeneration of synchronized wrapper (decorator).
13     /// TODO: Try to unfold code of each method using IL generation for performance improvements.
14     /// TODO: Or even to unfold multiple layers of implementations.
15     /// </remarks>
16     public class SynchronizedLinks<TLinkAddress> : ISynchronizedLinks<TLinkAddress>
17     {
18         public LinksConstants<TLinkAddress> Constants
19         {
20             [MethodImpl(MethodImplOptions.AggressiveInlining)]
21             get;
22         }
23
24         public ISynchronization SyncRoot
25         {
26             [MethodImpl(MethodImplOptions.AggressiveInlining)]
27             get;
28         }
29
30         public ILinks<TLinkAddress> Sync
31         {
32             [MethodImpl(MethodImplOptions.AggressiveInlining)]
33             get;
34         }
35
36         public ILinks<TLinkAddress> Unsync
37         {
38             [MethodImpl(MethodImplOptions.AggressiveInlining)]
39             get;
40         }
41
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public SynchronizedLinks(ILinks<TLinkAddress> links) : this(new
44             ↳ ReaderWriterLockSynchronization(), links) { }
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         public SynchronizedLinks(ISynchronization synchronization, ILinks<TLinkAddress> links)
48         {
49             SyncRoot = synchronization;
50             Sync = this;
51             Unsync = links;
52             Constants = links.Constants;
53         }
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         public TLinkAddress Count(IList<TLinkAddress> restriction) =>
57             ↳ SyncRoot.ExecuteReadOperation(restriction, Unsync.Count);
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         public TLinkAddress Each(Func<IList<TLinkAddress>, TLinkAddress> handler,
61             ↳ IList<TLinkAddress> restrictions) => SyncRoot.ExecuteReadOperation(handler,
62             ↳ restrictions, (handler1, restrictions1) => Unsync.Each(handler1, restrictions1));
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         public TLinkAddress Create(IList<TLinkAddress> restrictions) =>
66             ↳ SyncRoot.ExecuteWriteOperation(restrictions, Unsync.Create);
67
68         [MethodImpl(MethodImplOptions.AggressiveInlining)]
69         public TLinkAddress Update(IList<TLinkAddress> restrictions, IList<TLinkAddress>
70             ↳ substitution) => SyncRoot.ExecuteWriteOperation(restrictions, substitution,
71             ↳ Unsync.Update);
72
73         [MethodImpl(MethodImplOptions.AggressiveInlining)]
74         public void Delete(IList<TLinkAddress> restrictions) =>
75             ↳ SyncRoot.ExecuteWriteOperation(restrictions, Unsync.Delete);
76
77         //public T Trigger(IList<T> restriction, Func<IList<T>, IList<T>, T> matchedHandler,
78         //    ↳ IList<T> substitution, Func<IList<T>, IList<T>, T> substitutedHandler)
79         //{
80         //    if (restriction != null && substitution != null &&
81         //        ↳ !substitution.EqualTo(restriction))
82         //        return SyncRoot.ExecuteWriteOperation(restriction, matchedHandler,
83         //        ↳ substitution, substitutedHandler, Unsync.Trigger);
84     }
85 }

```

```

74         // return SyncRoot.ExecuteReadOperation(restriction, matchedHandler, substitution,
75         ↪ substitutedHandler, Unsync.Trigger);
76     //}
77 }

```

1.162 ./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>
15             ↪ int64ToLongRawNumberConverter) => _int64ToLongRawNumberConverter =
16             ↪ int64ToLongRawNumberConverter;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public TLink Convert(DateTime source) =>
20             ↪ _int64ToLongRawNumberConverter.Convert(source.ToFileTimeUtc());
21     }
22 }

```

1.163 ./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(IConverter<TLink, long>
15             ↪ longRawNumberConverterToInt64) => _longRawNumberConverterToInt64 =
16             ↪ longRawNumberConverterToInt64;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public DateTime Convert(TLink source) =>
20             ↪ DateTime.FromFileTimeUtc(_longRawNumberConverterToInt64.Convert(source));
21     }
22 }

```

1.164 ./csharp/Platform.Data.Doublets/UInt64LinksExtensions.cs

```

1  using System;
2  using System.Text;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Singletons;
6  using Platform.Data.Doublets.Unicode;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets
11 {
12     public static class UInt64LinksExtensions
13     {
14         public static readonly LinksConstants<ulong> Constants =
15             ↪ Default<LinksConstants<ulong>>.Instance;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public static void UseUnicode(this ILinks<ulong> links) => UnicodeMap.InitNew(links);
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public static bool AnyLinkIsAny(this ILinks<ulong> links, params ulong[] sequence)
22         {
23             if (sequence == null)
24             {
25                 return false;
26             }
27         }
28     }
29 }

```

```

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,
108                 ↪ appendElement, renderIndex);
109         }
110     }
111     sb.Append('');
112 }
113 else
114 {
115     if (renderDebug)
116     {
117         sb.Append('*');
118     }
119     sb.Append(linkIndex);
120 }
121 }
122 {
123     if (renderDebug)
124     {
125         sb.Append('~');
126     }
127     sb.Append(linkIndex);
128 }
129 }
130 }
131 }

```

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

```

1  using System;
2  using System.Linq;
3  using System.Collections.Generic;
4  using System.IO;
5  using System.Runtime.CompilerServices;
6  using System.Threading;
7  using System.Threading.Tasks;
8  using Platform.Disposables;
9  using Platform.Timestamps;
10 using Platform.Unsafe;
11 using Platform.IO;
12 using Platform.Data.Doublets.Decorators;
13 using Platform.Exceptions;
14
15 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
16
17 namespace Platform.Data.Doublets
18 {
19     public class UInt64LinksTransactionsLayer : LinksDisposableDecoratorBase<ulong> //-V3073
20     {
21         /// <remarks>
22         /// Альтернативные варианты хранения трансформации (элемента транзакции):
23         ///
24         /// private enum TransitionType
25         /// {
26         ///     Creation,
27         ///     UpdateOf,
28         ///     UpdateTo,
29         ///     Deletion
30         /// }
31         ///
32         /// private struct Transition
33         /// {
34         ///     public ulong TransactionId;
35         ///     public UniqueTimestamp Timestamp;
36         ///     public TransactionItemType Type;

```

```

37     ///     public Link Source;
38     ///     public Link Linker;
39     ///     public Link Target;
40     /// }
41     ///
42     /// Или
43     ///
44     /// public struct TransitionHeader
45     /// {
46     ///     public ulong TransactionIdCombined;
47     ///     public ulong TimestampCombined;
48     ///
49     ///     public ulong TransactionId
50     ///     {
51     ///         get
52     ///         {
53     ///             return (ulong) mask & TransactionIdCombined;
54     ///         }
55     ///     }
56     ///
57     ///     public UniqueTimestamp Timestamp
58     ///     {
59     ///         get
60     ///         {
61     ///             return (UniqueTimestamp)mask & TransactionIdCombined;
62     ///         }
63     ///     }
64     ///
65     ///     public TransactionItemType Type
66     ///     {
67     ///         get
68     ///         {
69     ///             // Использовать по одному биту из TransactionId и Timestamp,
70     ///             // для значения в 2 бита, которое представляет тип операции
71     ///             throw new NotImplementedException();
72     ///         }
73     ///     }
74     /// }
75     ///
76     /// private struct Transition
77     /// {
78     ///     public TransitionHeader Header;
79     ///     public Link Source;
80     ///     public Link Linker;
81     ///     public Link Target;
82     /// }
83     ///
84     </remarks>
85     public struct Transition : IEquatable<Transition>
86     {
87         public static readonly long Size = Structure<Transition>.Size;
88
89         public readonly ulong TransactionId;
90         public readonly Link<ulong> Before;
91         public readonly Link<ulong> After;
92         public readonly Timestamp Timestamp;
93
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)]

```

```

110     public override string ToString() => $"{Timestamp} {TransactionId}: {Before} =>
111         ↳ {After}";
112
113     [MethodImpl(MethodImplOptions.AggressiveInlining)]
114     public override bool Equals(object obj) => obj is Transition transition ?
115         ↳ Equals(transition) : false;
116
117     [MethodImpl(MethodImplOptions.AggressiveInlining)]
118     public override int GetHashCode() => (TransactionId, Before, After,
119         ↳ Timestamp).GetHashCode();
120
121     [MethodImpl(MethodImplOptions.AggressiveInlining)]
122     public bool Equals(Transition other) => TransactionId == other.TransactionId &&
123         ↳ Before == other.Before && After == other.After && Timestamp == other.Timestamp;
124
125     [MethodImpl(MethodImplOptions.AggressiveInlining)]
126     public static bool operator ==(Transition left, Transition right) =>
127         ↳ left.Equals(right);
128
129     [MethodImpl(MethodImplOptions.AggressiveInlining)]
130     public static bool operator !=(Transition left, Transition right) => !(left ==
131         ↳ right);
132 }
133
134 /// <remarks>
135 /// Другие варианты реализации транзакций (атомарности):
136 /// 1. Разделение хранения значения связи ((Source Target) или (Source Linker
137   ↳ Target)) и индексов.
138 /// 2. Хранение трансформаций/операций в отдельном хранилище Links, но дополнительно
139   ↳ потребуется решить вопрос
140 /// со ссылками на внешние идентификаторы, или как-то иначе решить вопрос с
141   ↳ пересечениями идентификаторов.
142 ///
143 /// Где хранить промежуточный список транзакций?
144 ///
145 /// В оперативной памяти:
146 /// Минусы:
147 /// 1. Может усложнить систему, если она будет функционировать самостоятельно,
148   ↳ так как нужно отдельно выделять память под список трансформаций.
149 /// 2. Выделенной оперативной памяти может не хватить, в том случае,
150   ↳ если транзакция использует слишком много трансформаций.
151 ///     -> Можно использовать жёсткий диск для слишком длинных транзакций.
152 ///     -> Максимальный размер списка трансформаций можно ограничить / задать
153   ↳ константой.
154 /// 3. При подтверждении транзакции (Commit) все трансформации записываются разом
155   ↳ создавая задержку.
156 ///
157 /// На жёстком диске:
158 /// Минусы:
159 /// 1. Длительный отклик, на запись каждой трансформации.
160 /// 2. Лог транзакций дополнительно наполняется отменёнными транзакциями.
161   ↳ -> Это может решаться упаковкой/исключением дублирующих операций.
162   ↳ -> Также это может решаться тем, что короткие транзакции вообще
163       ↳ не будут записываться в случае отката.
164 /// 3. Перед тем как выполнять отмену операций транзакции нужно дождаться пока все
165   ↳ операции (трансформации)
166       ↳ будут записаны в лог.
167 /// </remarks>
168 public class Transaction : DisposableBase
169 {
170     private readonly Queue<Transition> _transitions;
171     private readonly UInt64LinksTransactionsLayer _layer;
172     public bool IsCommitted { get; private set; }
173     public bool IsReverted { get; private set; }
174
175     [MethodImpl(MethodImplOptions.AggressiveInlining)]
176     public Transaction(UInt64LinksTransactionsLayer layer)
177     {
178         _layer = layer;
179         if (_layer._currentTransactionId != 0)
180         {
181             throw new NotSupportedException("Nested transactions not supported.");
182         }
183         IsCommitted = false;
184         IsReverted = false;
185         _transitions = new Queue<Transition>();
186         SetCurrentTransaction(layer, this);
187     }
188 }

```

```

176     }
177
178     [MethodImpl(MethodImplOptions.AggressiveInlining)]
179     public void Commit()
180     {
181         EnsureTransactionAllowsWriteOperations(this);
182         while (_transitions.Count > 0)
183         {
184             var transition = _transitions.Dequeue();
185             _layer._transitions.Enqueue(transition);
186         }
187         _layer._lastCommittedTransactionId = _layer._currentTransactionId;
188         IsCommitted = true;
189     }
190
191     [MethodImpl(MethodImplOptions.AggressiveInlining)]
192     private void Revert()
193     {
194         EnsureTransactionAllowsWriteOperations(this);
195         var transitionsToRevert = new Transition[_transitions.Count];
196         _transitions.CopyTo(transitionsToRevert, 0);
197         for (var i = transitionsToRevert.Length - 1; i >= 0; i--)
198         {
199             _layer.RevertTransition(transitionsToRevert[i]);
200         }
201         IsReverted = true;
202     }
203
204     [MethodImpl(MethodImplOptions.AggressiveInlining)]
205     public static void SetCurrentTransaction(UInt64LinksTransactionsLayer layer,
206     ↪ Transaction transaction)
207     {
208         layer._currentTransactionId = layer._lastCommittedTransactionId + 1;
209         layer._currentTransactionTransitions = transaction._transitions;
210         layer._currentTransaction = transaction;
211     }
212
213     [MethodImpl(MethodImplOptions.AggressiveInlining)]
214     public static void EnsureTransactionAllowsWriteOperations(Transaction transaction)
215     {
216         if (transaction.IsReverted)
217         {
218             throw new InvalidOperationException("Transation is reverted.");
219         }
220         if (transaction.IsCommitted)
221         {
222             throw new InvalidOperationException("Transation is committed.");
223         }
224     }
225
226     [MethodImpl(MethodImplOptions.AggressiveInlining)]
227     protected override void Dispose(bool manual, bool wasDisposed)
228     {
229         if (!wasDisposed && _layer != null && !_layer.Disposable.IsDisposed)
230         {
231             if (!IsCommitted && !IsReverted)
232             {
233                 Revert();
234             }
235             _layer.ResetCurrentTransation();
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 законченная транзакция.
261     // При запуске это используется для проверки удачного закрытия файла лога.
262     // In the first line of the file the last committed transaction is stored.
263     // On startup, this is used to check that the log file is successfully closed.
264     var lastCommittedTransition = FileHelpers.ReadFirstOrDefault<Transition>(logAddress);
265     var lastWrittenTransition = FileHelpers.ReadLastOrDefault<Transition>(logAddress);
266     if (!lastCommittedTransition.Equals(lastWrittenTransition))
267     {
268         Dispose();
269         throw new NotSupportedException("Database is damaged, autorecovery is not
270             ↳ supported yet.");
271     }
272     if (lastCommittedTransition == default)
273     {
274         FileHelpers.WriteFirst(logAddress, lastCommittedTransition);
275     }
276     _lastCommittedTransition = lastCommittedTransition;
277     // TODO: Think about a better way to calculate or store this value
278     var allTransitions = FileHelpers.ReadAll<Transition>(logAddress);
279     _lastCommittedTransactionId = allTransitions.Length > 0 ? allTransitions.Max(x =>
280         ↳ x.TransactionId) : 0;
281     _uniqueTimestampFactory = new UniqueTimestampFactory();
282     _logAddress = logAddress;
283     _log = FileHelpers.Append(logAddress);
284     _transitions = new Queue<Transition>();
285     _transitionsPusher = new Task(TransitionsPusher);
286     _transitionsPusher.Start();
287 }
288
289 [MethodImpl(MethodImplOptions.AggressiveInlining)]
290 public IList<ulong> GetLinkValue(ulong link) => _links.GetLink(link);
291
292 [MethodImpl(MethodImplOptions.AggressiveInlining)]
293 public override ulong Create(IList<ulong> restrictions)
294 {
295     var createdLinkIndex = _links.Create();
296     var createdLink = new Link<ulong>(_links.GetLink(createdLinkIndex));
297     CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
298         ↳ default, createdLink));
299     return createdLinkIndex;
300 }
301
302 [MethodImpl(MethodImplOptions.AggressiveInlining)]
303 public override ulong Update(IList<ulong> restrictions, IList<ulong> substitution)
304 {
305     var linkIndex = restrictions[_constants.IndexPart];
306     var beforeLink = new Link<ulong>(_links.GetLink(linkIndex));
307     linkIndex = _links.Update(restrictions, substitution);
308     var afterLink = new Link<ulong>(_links.GetLink(linkIndex));
309     CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
310         ↳ beforeLink, afterLink));
311     return linkIndex;
312 }
313
314 [MethodImpl(MethodImplOptions.AggressiveInlining)]
315 public override void Delete(IList<ulong> restrictions)
316 {
317     var link = restrictions[_constants.IndexPart];
318     var deletedLink = new Link<ulong>(_links.GetLink(link));
319     _links.Delete(link);
320     CommitTransition(new Transition(_uniqueTimestampFactory, _currentTransactionId,
321         ↳ deletedLink, default));
322 }
323
324 [MethodImpl(MethodImplOptions.AggressiveInlining)]
325 private Queue<Transition> GetCurrentTransitions() => _currentTransactionTransitions ??
326     ↳ _transitions;
327
328 [MethodImpl(MethodImplOptions.AggressiveInlining)]
329 private void CommitTransition(Transition transition)
330 {
331     if (_currentTransaction != null)
332     {
333

```

```

327         Transaction.EnsureTransactionAllowsWriteOperations(_currentTransaction);
328     }
329     var transitions = GetCurrentTransitions();
330     transitions.Enqueue(transition);
331 }
332
333 [MethodImpl(MethodImplOptions.AggressiveInlining)]
334 private void RevertTransition(Transition transition)
335 {
336     if (transition.After.IsNull()) // Revert Deletion with Creation
337     {
338         _links.Create();
339     }
340     else if (transition.Before.IsNull()) // Revert Creation with Deletion
341     {
342         _links.Delete(transition.After.Index);
343     }
344     else // Revert Update
345     {
346         _links.Update(new[] { transition.After.Index, transition.Before.Source,
347             ↪ transition.Before.Target });
348     }
349 }
350
351 [MethodImpl(MethodImplOptions.AggressiveInlining)]
352 private void ResetCurrentTransation()
353 {
354     _currentTransactionId = 0;
355     _currentTransactionTransitions = null;
356     _currentTransaction = null;
357 }
358
359 [MethodImpl(MethodImplOptions.AggressiveInlining)]
360 private void PushTransitions()
361 {
362     if (_log == null || _transitions == null)
363     {
364         return;
365     }
366     for (var i = 0; i < _transitions.Count; i++)
367     {
368         var transition = _transitions.Dequeue();
369
370         _log.Write(transition);
371         _lastCommittedTransition = transition;
372     }
373 }
374
375 [MethodImpl(MethodImplOptions.AggressiveInlining)]
376 private void TransitionsPusher()
377 {
378     while (!Disposable.IsDisposed && _transitionsPusher != null)
379     {
380         Thread.Sleep(DefaultPushDelay);
381         PushTransitions();
382     }
383 }
384
385 [MethodImpl(MethodImplOptions.AggressiveInlining)]
386 public Transaction BeginTransaction() => new Transaction(this);
387
388 [MethodImpl(MethodImplOptions.AggressiveInlining)]
389 private void DisposeTransitions()
390 {
391     try
392     {
393         var pusher = _transitionsPusher;
394         if (pusher != null)
395         {
396             _transitionsPusher = null;
397             pusher.Wait();
398         }
399         if (_transitions != null)
400         {
401             PushTransitions();
402         }
403         _log.DisposeIfPossible();
404         FileHelpers.WriteFirst(_logAddress, _lastCommittedTransition);
405     }

```

```

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 }

```

1.166 ./csharp/Platform.Data.Doublets/Unicode/CharToUnicodeSymbolConverter.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Converters;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Unicode
7  {
8      public class CharToUnicodeSymbolConverter<TLink> : LinksOperatorBase<TLink>,
9          ↪ IConverter<char, TLink>
10     {
11         private static readonly UncheckedConverter<char, TLink> _charToAddressConverter =
12             ↪ UncheckedConverter<char, TLink>.Default;
13
14         private readonly IConverter<TLink> _addressToNumberConverter;
15         private readonly TLink _unicodeSymbolMarker;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public CharToUnicodeSymbolConverter(ILinks<TLink> links, IConverter<TLink>
19             ↪ addressToNumberConverter, TLink unicodeSymbolMarker) : base(links)
20         {
21             _addressToNumberConverter = addressToNumberConverter;
22             _unicodeSymbolMarker = unicodeSymbolMarker;
23         }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public TLink Convert(char source)
27         {
28             var unaryNumber =
29                 ↪ _addressToNumberConverter.Convert(_charToAddressConverter.Convert(source));
30             return _links.GetOrCreate(unaryNumber, _unicodeSymbolMarker);
31         }
32     }
33 }

```

1.167 ./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 }

```

```

20     }
21
22     [MethodImpl(MethodImplOptions.AggressiveInlining)]
23     public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<string,
    ↪ IList<TLink>> stringToUnicodeSymbolListConverter, ISequenceIndex<TLink> index,
    ↪ IConverter<IList<TLink>, TLink> listToSequenceLinkConverter, TLink
    ↪ unicodeSequenceMarker)
24     : this(links, stringToUnicodeSymbolListConverter, new
    ↪ UnicodeSymbolsListToUnicodeSequenceConverter<TLink>(links, index,
    ↪ listToSequenceLinkConverter, unicodeSequenceMarker)) { }
25
26     [MethodImpl(MethodImplOptions.AggressiveInlining)]
27     public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<char, TLink>
    ↪ charToUnicodeSymbolConverter, ISequenceIndex<TLink> index, IConverter<IList<TLink>,
    ↪ TLink> listToSequenceLinkConverter, TLink unicodeSequenceMarker)
28     : this(links, new
    ↪ StringToUnicodeSymbolsListConverter<TLink>(charToUnicodeSymbolConverter), index,
    ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<char, TLink>
    ↪ charToUnicodeSymbolConverter, IConverter<IList<TLink>, TLink>
    ↪ listToSequenceLinkConverter, TLink unicodeSequenceMarker)
32     : this(links, charToUnicodeSymbolConverter, new Unindex<TLink>(),
    ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<string,
    ↪ IList<TLink>> stringToUnicodeSymbolListConverter, IConverter<IList<TLink>, TLink>
    ↪ listToSequenceLinkConverter, TLink unicodeSequenceMarker)
36     : this(links, stringToUnicodeSymbolListConverter, new Unindex<TLink>(),
    ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     public TLink Convert(string source)
40     {
41         var elements = _stringToUnicodeSymbolListConverter.Convert(source);
42         return _unicodeSymbolListToSequenceConverter.Convert(elements);
43     }
44 }
45 }

```

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

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Unicode
8 {
9     public class StringToUnicodeSymbolsListConverter<TLink> : IConverter<string, IList<TLink>>
10     {
11         private readonly IConverter<char, TLink> _charToUnicodeSymbolConverter;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public StringToUnicodeSymbolsListConverter(IConverter<char, TLink>
    ↪ charToUnicodeSymbolConverter) => _charToUnicodeSymbolConverter =
    ↪ charToUnicodeSymbolConverter;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public IList<TLink> Convert(string source)
18         {
19             var elements = new TLink[source.Length];
20             for (var i = 0; i < elements.Length; i++)
21             {
22                 elements[i] = _charToUnicodeSymbolConverter.Convert(source[i]);
23             }
24             return elements;
25         }
26     }
27 }

```

1.169 ./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
61             // 0 - null link
62             // 1 - nil character (0 character)
63             // ...
64             // 65536 (0(1) + 65535 = 65536 possible values)
65
66             [MethodImpl(MethodImplOptions.AggressiveInlining)]
67             public static ulong FromCharToLink(char character) => (ulong)character + 1;
68
69             [MethodImpl(MethodImplOptions.AggressiveInlining)]
70             public static char FromLinkToChar(ulong link) => (char)(link - 1);
71
72             [MethodImpl(MethodImplOptions.AggressiveInlining)]
73             public static bool IsCharLink(ulong link) => link <= MapSize;
74
75             [MethodImpl(MethodImplOptions.AggressiveInlining)]
76             public static string FromLinksToString(IList<ulong> linksList)
77             {
78                 var sb = new StringBuilder();
79                 for (int i = 0; i < linksList.Count; i++)
80                 {
81                     sb.Append(FromLinkToChar(linksList[i]));
82                 }
83             }
84         }
85     }
86 }

```

```

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     {
125         linksSequence[i] = FromCharToLink(sequence[i]);
126     }
127     return linksSequence;
128 }
129
130 [MethodImpl(MethodImplOptions.AggressiveInlining)]
131 public static List<ulong[]> FromStringToLinkArrayGroups(string sequence)
132 {
133     var result = new List<ulong[]>();
134     var offset = 0;
135     while (offset < sequence.Length)
136     {
137         var currentCategory = CharUnicodeInfo.GetUnicodeCategory(sequence[offset]);
138         var relativeLength = 1;
139         var absoluteLength = offset + relativeLength;
140         while (absoluteLength < sequence.Length &&
141             currentCategory ==
142             ↪ CharUnicodeInfo.GetUnicodeCategory(sequence[absoluteLength]))
143         {
144             relativeLength++;
145             absoluteLength++;
146         }
147         // char array to ulong array
148         var innerSequence = new ulong[relativeLength];
149         var maxLength = offset + relativeLength;
150         for (var i = offset; i < maxLength; i++)
151         {
152             innerSequence[i - offset] = FromCharToLink(sequence[i]);
153         }
154         result.Add(innerSequence);
155         offset += relativeLength;
156     }
157     return result;
158 }
159
160 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

158 public static List<ulong[]> FromLinkArrayToLinkArrayGroups(ulong[] array)
159 {
160     var result = new List<ulong[]>();
161     var offset = 0;
162     while (offset < array.Length)
163     {
164         var relativeLength = 1;
165         if (array[offset] <= LastCharLink)
166         {
167             var currentCategory =
168                 CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(array[offset]));
169             var absoluteLength = offset + relativeLength;
170             while (absoluteLength < array.Length &&
171                 array[absoluteLength] <= LastCharLink &&
172                 currentCategory == CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(
173                     array[absoluteLength])))
174             {
175                 relativeLength++;
176                 absoluteLength++;
177             }
178         }
179         else
180         {
181             var absoluteLength = offset + relativeLength;
182             while (absoluteLength < array.Length && array[absoluteLength] > LastCharLink)
183             {
184                 relativeLength++;
185                 absoluteLength++;
186             }
187             // copy array
188             var innerSequence = new ulong[relativeLength];
189             var maxLength = offset + relativeLength;
190             for (var i = offset; i < maxLength; i++)
191             {
192                 innerSequence[i - offset] = array[i];
193             }
194             result.Add(innerSequence);
195             offset += relativeLength;
196         }
197     }
198     return result;
199 }

```

1.170 ./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             {

```

```

31         throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
           ↪ not a unicode sequence.");
32     }
33     var sequence = _links.GetSource(source);
34     var sb = new StringBuilder();
35     foreach(var character in _sequenceWalker.Walk(sequence))
36     {
37         sb.Append(_unicodeSymbolToCharConverter.Convert(character));
38     }
39     return sb.ToString();
40 }
41 }
42 }

```

1.171 ./csharp/Platform.Data.Doublets/Unicode/UnicodeSymbolToCharConverter.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Converters;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Unicode
9  {
10     public class UnicodeSymbolToCharConverter<TLink> : LinksOperatorBase<TLink>,
           ↪ IConverter<TLink, char>
11     {
12         private static readonly UncheckedConverter<TLink, char> _addressToCharConverter =
           ↪ UncheckedConverter<TLink, char>.Default;
13
14         private readonly IConverter<TLink> _numberToAddressConverter;
15         private readonly ICriterionMatcher<TLink> _unicodeSymbolCriterionMatcher;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public UnicodeSymbolToCharConverter(ILinks<TLink> links, IConverter<TLink>
           ↪ numberToAddressConverter, ICriterionMatcher<TLink> unicodeSymbolCriterionMatcher) :
           ↪ base(links)
19         {
20             _numberToAddressConverter = numberToAddressConverter;
21             _unicodeSymbolCriterionMatcher = unicodeSymbolCriterionMatcher;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public char Convert(TLink source)
26         {
27             if (!_unicodeSymbolCriterionMatcher.IsMatched(source))
28             {
29                 throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
           ↪ not a unicode symbol.");
30             }
31             return _addressToCharConverter.Convert(_numberToAddressConverter.Convert(_links.GetS
           ↪ ource(source)));
32         }
33     }
34 }

```

1.172 ./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 }

```

1.173 ./csharp/Platform.Data.Doublets.Tests/DefaultSequenceAppenderTests.cs

```

1  using System.Collections.Generic;
2  using Platform.Collections.Stacks;
3  using Platform.Data.Doublets.Memory;
4  using Platform.Data.Doublets.Memory.United.Generic;
5  using Platform.Data.Doublets.Sequences;
6  using Platform.Data.Doublets.Sequences.HeightProviders;
7  using Platform.Data.Numbers.Raw;
8  using Platform.Interfaces;
9  using Platform.Memory;
10 using Platform.Numbers;
11 using Xunit;
12 using Xunit.Abstractions;
13 using TLink = System.UInt64;
14
15 namespace Platform.Data.Doublets.Tests
16 {
17     public class DefaultSequenceAppenderTests
18     {
19         private readonly ITestOutputHelper _output;
20
21         public DefaultSequenceAppenderTests(ITestOutputHelper output)
22         {
23             _output = output;
24         }
25         public static ILinks<TLink> CreateLinks() => CreateLinks<TLink>(new IO.TemporaryFile());
26
27         public static ILinks<TLink> CreateLinks<TLink>(string dataDBFilename)
28         {
29             var linksConstants = new LinksConstants<TLink>(enableExternalReferencesSupport:
    ↪ true);
30             return new UnitedMemoryLinks<TLink>(new
    ↪ FileMappedResizableDirectMemory(dataDBFilename),
    ↪ UnitedMemoryLinks<TLink>.DefaultLinksSizeStep, linksConstants,
    ↪ IndexTreeType.Default);
31         }
32
33         public class ValueCriterionMatcher<TLink> : ICriterionMatcher<TLink>
34         {
35             public readonly ILinks<TLink> Links;
36             public readonly TLink Marker;
37             public ValueCriterionMatcher(ILinks<TLink> links, TLink marker)
38             {
39                 Links = links;
40                 Marker = marker;
41             }
42
43             public bool IsMatched(TLink link) =>
    ↪ EqualityComparer<TLink>.Default.Equals(Links.GetSource(link), Marker);
44         }
45
46         [Fact]
47         public void AppendArrayBug()
48         {
49             ILinks<TLink> links = CreateLinks();
50             TLink zero = default;
51             var markerIndex = Arithmetic.Increment(zero);
52             var meaningRoot = links.GetOrCreate(markerIndex, markerIndex);
53             var sequence = links.Create();

```

```

54     sequence = links.Update(sequence, meaningRoot, sequence);
55     var appendant = links.Create();
56     appendant = links.Update(appendant, meaningRoot, appendant);
57     ValueCriterionMatcher<TLink> valueCriterionMatcher = new(links, meaningRoot);
58     DefaultSequenceRightHeightProvider<ulong> defaultSequenceRightHeightProvider =
        ↳ new(links, valueCriterionMatcher);
59     DefaultSequenceAppender<TLink> defaultSequenceAppender = new(links, new
        ↳ DefaultStack<ulong>(), defaultSequenceRightHeightProvider);
60     var newArray = defaultSequenceAppender.Append(sequence, appendant);
61     var output = links.FormatStructure(newArray, link => link.IsFullPoint(), true);
62     Assert.Equal("(4:(2:1 2) (3:1 3))", output);
63 }
64 }
65 }

```

1.174 ./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
        ↳ MultipleRandomCreationsAndDeletions(16)); // Cannot use more because current
        ↳ implementation of tree cuts out 5 bits from the address space.
34             Using<ushort>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Te
        ↳ stMultipleRandomCreationsAndDeletions(100));
35             Using<uint>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
        ↳ MultipleRandomCreationsAndDeletions(100));
36             Using<ulong>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Tes
        ↳ tMultipleRandomCreationsAndDeletions(100));
37         }
38
39         private static void Using<TLink>(Action<ILinks<TLink>> action)
40         {
41             using (var scope = new Scope<Types<HeapResizableDirectMemory,
        ↳ UnitedMemoryLinks<TLink>>>())
42             {
43                 action(scope.Use<ILinks<TLink>>>());
44             }
45         }
46     }
47 }

```

1.175 ./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 }

```

1.176 ./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 }

```

1.177 ./csharp/Platform.Data.Doublets.Tests/Numbers/Raw/BigIntegerConvertersTests.cs

```

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

```

```

35     [Fact (Skip = "Does not work yet.")]
36     public void Test64BitNumber()
37     {
38         var links = CreateLinks();
39         BigInteger bigInt = new(ulong.MaxValue);
40         AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
41         RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
42         BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
43             ↪ = new(links, addressToRawNumberConverter);
44         RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
45             ↪ = new(links, numberToAddressConverter);
46         var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInt);
47         var bigIntFromSequence =
48             ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
49         Assert.Equal(bigInt, bigIntFromSequence);
50     }
51 }
52 }

```

1.178 ./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,
28             ↪ consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore
29             ↪ magna aliqua.
30             ↪ Facilisi nullam vehicula ipsum a arcu cursus vitae congue mauris.
31             ↪ Et malesuada fames ac turpis egestas sed.
32             ↪ Eget velit aliquet sagittis id consectetur purus.
33             ↪ Dignissim cras tincidunt lobortis feugiat vivamus.
34             ↪ Vitae aliquet nec ullamcorper sit.
35             ↪ Lectus quam id leo in vitae.
36             ↪ Tortor dignissim convallis aenean et tortor at risus viverra adipiscing.
37             ↪ Sed risus ultricies tristique nulla aliquet enim tortor at auctor.
38             ↪ Integer eget aliquet nibh praesent tristique.
39             ↪ Vitae congue eu consequat ac felis donec et odio.
40             ↪ Tristique et egestas quis ipsum suspendisse.
41             ↪ Suspendisse potenti nullam ac tortor vitae purus faucibus ornare.
42             ↪ Nulla facilisi etiam dignissim diam quis enim lobortis scelerisque.
43             ↪ Imperdiet proin fermentum leo vel orci.
44             ↪ In ante metus dictum at tempor commodo.
45             ↪ Nisi lacus sed viverra tellus in.
46             ↪ Quam vulputate dignissim suspendisse in.
47             ↪ Elit scelerisque mauris pellentesque pulvinar pellentesque habitant morbi tristique senectus.
48             ↪ Gravida cum sociis natoque penatibus et magnis dis parturient.
49             ↪ Risus quis varius quam quisque id diam.
50             ↪ Congue nisi vitae suscipit tellus mauris a diam maecenas.
51             ↪ Eget nunc scelerisque viverra mauris in aliquam sem fringilla.
52             ↪ Pharetra vel turpis nunc eget lorem dolor sed viverra.
53             ↪ Mattis pellentesque id nibh tortor id aliquet.
54             ↪ Purus non enim praesent elementum facilisis leo vel.
55             ↪ Etiam sit amet nisl purus in mollis nunc sed.
56             ↪ Tortor at auctor urna nunc id cursus metus aliquam.
57             ↪ Volutpat odio facilisis mauris sit amet.
58             ↪ Turpis egestas pretium aenean pharetra magna ac placerat.
59             ↪ Fermentum dui faucibus in ornare quam viverra orci sagittis eu.
60             ↪ Porttitor leo a diam sollicitudin tempor id eu.
61             ↪ Volutpat sed cras ornare arcu dui.
62             ↪ Ut aliquam purus sit amet luctus venenatis lectus magna.
63             ↪ Aliquet risus feugiat in ante metus dictum at.

```



```

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);

```

```

126     var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache);
127     ↪
128     var sequenceToItsLocalElementLevelsConverter = new
129     ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
130     ↪ linkToItsFrequencyNumberConverter);
131     var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
132     ↪ sequenceToItsLocalElementLevelsConverter);
133
134     var sequences = new Sequences.Sequences(links, new SequencesOptions<ulong>() {
135     ↪ Walker = new LeveledSequenceWalker<ulong>(links) });
136
137     ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
138     ↪ index, optimalVariantConverter);
139 }
140
141 private static void ExecuteTest(Sequences.Sequences sequences, ulong[] sequence,
142     ↪ SequenceToItsLocalElementLevelsConverter<ulong>
143     ↪ sequenceToItsLocalElementLevelsConverter, ISequenceIndex<ulong> index,
144     ↪ OptimalVariantConverter<ulong> optimalVariantConverter)
145 {
146     index.Add(sequence);
147
148     var optimalVariant = optimalVariantConverter.Convert(sequence);
149
150     var readSequence1 = sequences.ToList(optimalVariant);
151
152     Assert.True(sequence.SequenceEqual(readSequence1));
153 }
154
155 [Fact]
156 public static void SavedSequencesOptimizationTest()
157 {
158     LinksConstants<ulong> constants = new LinksConstants<ulong>((1, long.MaxValue),
159     ↪ (long.MaxValue + 1UL, ulong.MaxValue));
160
161     using (var memory = new HeapResizableDirectMemory())
162     using (var disposableLinks = new UInt64UnitedMemoryLinks(memory,
163     ↪ UInt64UnitedMemoryLinks.DefaultLinksSizeStep, constants, IndexTreeType.Default))
164     {
165         var links = new UInt64Links(disposableLinks);
166
167         var root = links.CreatePoint();
168
169         //var numberToAddressConverter = new RawNumberToAddressConverter<ulong>();
170         var addressToNumberConverter = new AddressToRawNumberConverter<ulong>();
171
172         var unicodeSymbolMarker = links.GetOrCreate(root,
173     ↪ addressToNumberConverter.Convert(1));
174         var unicodeSequenceMarker = links.GetOrCreate(root,
175     ↪ addressToNumberConverter.Convert(2));
176
177         var totalSequenceSymbolFrequencyCounter = new
178     ↪ TotalSequenceSymbolFrequencyCounter<ulong>(links);
179         var linkFrequenciesCache = new LinkFrequenciesCache<ulong>(links,
180     ↪ totalSequenceSymbolFrequencyCounter);
181         var index = new
182     ↪ CachedFrequencyIncrementingSequenceIndex<ulong>(linkFrequenciesCache);
183         var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache);
184         var sequenceToItsLocalElementLevelsConverter = new
185     ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
186     ↪ linkToItsFrequencyNumberConverter);
187         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
188     ↪ sequenceToItsLocalElementLevelsConverter);
189
190         var walker = new RightSequenceWalker<ulong>(links, new DefaultStack<ulong>(),
191     ↪ (link) => constants.IsExternalReference(link) || links.IsPartialPoint(link));
192
193         var unicodeSequencesOptions = new SequencesOptions<ulong>()
194     {
195             UseSequenceMarker = true,
196             SequenceMarkerLink = unicodeSequenceMarker,
197             UseIndex = true,
198             Index = index,
199             LinksToSequenceConverter = optimalVariantConverter,
200             Walker = walker,

```



```

45         readSequence2.Add());
46     sw3.Stop();
47     Assert.True(sequence.SequenceEqual(readSequence1));
48     Assert.True(sequence.SequenceEqual(readSequence2));
49     // Assert.True(sw2.Elapsed < sw3.Elapsed);
50     Console.WriteLine($"Stack-based walker: {sw3.Elapsed}, Level-based reader:
51     ↪ {sw2.Elapsed}");
52     for (var i = 0; i < sequenceLength; i++)
53     {
54         links.Delete(sequence[i]);
55     }
56 }
57 }
58 }
59 }
60 }
61 }
62 }
63 }

```

1.180 ./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
37         private static void TestBasicMemoryOperations(this ILinks<ulong> memoryAdapter)
38         {
39             var link = memoryAdapter.Create();
40             memoryAdapter.Delete(link);
41         }
42
43         [Fact]
44         public static void NonexistentReferencesHeapMemoryTest()
45         {
46             using (var memory = new
47                 ↪ HeapResizableDirectMemory(UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
48             using (var memoryAdapter = new UInt64UnitedMemoryLinks(memory,
49                 ↪ UInt64UnitedMemoryLinks.DefaultLinksSizeStep))
50             {
51                 memoryAdapter.TestNonexistentReferences();
52             }
53         }
54
55         private static void TestNonexistentReferences(this ILinks<ulong> memoryAdapter)
56         {
57             var link = memoryAdapter.Create();
58         }
59     }
60 }

```

```

53     memoryAdapter.Update(link, ulong.MaxValue, ulong.MaxValue);
54     var resultLink = _constants.Null;
55     memoryAdapter.Each(foundLink =>
56     {
57         resultLink = foundLink[_constants.IndexPart];
58         return _constants.Break;
59     }, _constants.Any, ulong.MaxValue, ulong.MaxValue);
60     Assert.True(resultLink == link);
61     Assert.True(memoryAdapter.Count(ulong.MaxValue) == 0);
62     memoryAdapter.Delete(link);
63 }
64 }
65 }

```

1.181 ./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     }

```

1.182 ./csharp/Platform.Data.Doublets.Tests/SequencesTests.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Diagnostics;
4  using System.Linq;
5  using Xunit;

```

```

6 using Platform.Collections;
7 using Platform.Collections.Arrays;
8 using Platform.Random;
9 using Platform.IO;
10 using Platform.Singletons;
11 using Platform.Data.Doublets.Sequences;
12 using Platform.Data.Doublets.Sequences.Frequencies.Cache;
13 using Platform.Data.Doublets.Sequences.Frequencies.Counters;
14 using Platform.Data.Doublets.Sequences.Converters;
15 using Platform.Data.Doublets.Unicode;
16
17 namespace Platform.Data.Doublets.Tests
18 {
19     public static class SequencesTests
20     {
21         private static readonly LinksConstants<ulong> _constants =
22             ↪ Default<LinksConstants<ulong>>.Instance;
23
24         static SequencesTests()
25         {
26             // Trigger static constructor to not mess with performance measurements
27             _ = BitString.GetBitMaskFromIndex(1);
28         }
29
30         [Fact]
31         public static void CreateAllVariantsTest()
32         {
33             const long sequenceLength = 8;
34
35             using (var scope = new TempLinksTestScope(useSequences: true))
36             {
37                 var links = scope.Links;
38                 var sequences = scope.Sequences;
39
40                 var sequence = new ulong[sequenceLength];
41                 for (var i = 0; i < sequenceLength; i++)
42                 {
43                     sequence[i] = links.Create();
44                 }
45
46                 var sw1 = Stopwatch.StartNew();
47                 var results1 = sequences.CreateAllVariants1(sequence); sw1.Stop();
48
49                 var sw2 = Stopwatch.StartNew();
50                 var results2 = sequences.CreateAllVariants2(sequence); sw2.Stop();
51
52                 Assert.True(results1.Count > results2.Length);
53                 Assert.True(sw1.Elapsed > sw2.Elapsed);
54
55                 for (var i = 0; i < sequenceLength; i++)
56                 {
57                     links.Delete(sequence[i]);
58                 }
59
60                 Assert.True(links.Count() == 0);
61             }
62         }
63
64         // [Fact]
65         // public void CUDTest()
66         // {
67         //     var tempFilename = Path.GetTempFileName();
68
69         //     const long sequenceLength = 8;
70
71         //     const ulong itself = LinksConstants.Itself;
72
73         //     using (var memoryAdapter = new ResizableDirectMemoryLinks(tempFilename,
74         // ↪ DefaultLinksSizeStep))
75         //     using (var links = new Links(memoryAdapter))
76         //     {
77         //         var sequence = new ulong[sequenceLength];
78         //         for (var i = 0; i < sequenceLength; i++)
79         //             sequence[i] = links.Create(itself, itself);
80
81         //         SequencesOptions o = new SequencesOptions();
82
83         //         // TODO: Из числа в bool значения o.UseSequenceMarker = ((value & 1) != 0)
84         //         o.

```

```

84         //         var sequences = new Sequences(links);
85
86         //         var sw1 = Stopwatch.StartNew();
87         //         var results1 = sequences.CreateAllVariants1(sequence); sw1.Stop();
88
89         //         var sw2 = Stopwatch.StartNew();
90         //         var results2 = sequences.CreateAllVariants2(sequence); sw2.Stop();
91
92         //         Assert.True(results1.Count > results2.Length);
93         //         Assert.True(sw1.Elapsed > sw2.Elapsed);
94
95         //         for (var i = 0; i < sequenceLength; i++)
96         //             links.Delete(sequence[i]);
97         //     }
98
99     //     File.Delete(tempFilename);
100 //}
101
102 [Fact]
103 public static void AllVariantsSearchTest()
104 {
105     const long sequenceLength = 8;
106
107     using (var scope = new TempLinksTestScope(useSequences: true))
108     {
109         var links = scope.Links;
110         var sequences = scope.Sequences;
111
112         var sequence = new ulong[sequenceLength];
113         for (var i = 0; i < sequenceLength; i++)
114         {
115             sequence[i] = links.Create();
116         }
117
118         var createResults = sequences.CreateAllVariants2(sequence).Distinct().ToArray();
119
120         //for (int i = 0; i < createResults.Length; i++)
121         //    sequences.Create(createResults[i]);
122
123         var sw0 = Stopwatch.StartNew();
124         var searchResults0 = sequences.GetAllMatchingSequences0(sequence); sw0.Stop();
125
126         var sw1 = Stopwatch.StartNew();
127         var searchResults1 = sequences.GetAllMatchingSequences1(sequence); sw1.Stop();
128
129         var sw2 = Stopwatch.StartNew();
130         var searchResults2 = sequences.Each1(sequence); sw2.Stop();
131
132         var sw3 = Stopwatch.StartNew();
133         var searchResults3 = sequences.Each(sequence.ShiftRight()); sw3.Stop();
134
135         var intersection0 = createResults.Intersect(searchResults0).ToList();
136         Assert.True(intersection0.Count == searchResults0.Count);
137         Assert.True(intersection0.Count == createResults.Length);
138
139         var intersection1 = createResults.Intersect(searchResults1).ToList();
140         Assert.True(intersection1.Count == searchResults1.Count);
141         Assert.True(intersection1.Count == createResults.Length);
142
143         var intersection2 = createResults.Intersect(searchResults2).ToList();
144         Assert.True(intersection2.Count == searchResults2.Count);
145         Assert.True(intersection2.Count == createResults.Length);
146
147         var intersection3 = createResults.Intersect(searchResults3).ToList();
148         Assert.True(intersection3.Count == searchResults3.Count);
149         Assert.True(intersection3.Count == createResults.Length);
150
151         for (var i = 0; i < sequenceLength; i++)
152         {
153             links.Delete(sequence[i]);
154         }
155     }
156 }
157
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();

```



```

238 //Global.Trash = searchResults3;
239
240 //var searchResults1Strings = searchResults1.Select(x => x + ": " +
241 ↪ sequences.FormatSequence(x)).ToList();
242 //Global.Trash = searchResults1Strings;
243
244 var intersection1 = createResults.Intersect(searchResults1).ToList();
245 Assert.True(intersection1.Count == createResults.Length);
246
247 var intersection2 = createResults.Intersect(searchResults2).ToList();
248 Assert.True(intersection2.Count == createResults.Length);
249
250 var intersection4 = createResults.Intersect(searchResults4).ToList();
251 Assert.True(intersection4.Count == createResults.Length);
252
253 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
293         Assert.True(searchResults2.Count == 1 && balancedVariant ==
294             ↪ searchResults2.First());
295
296         for (var i = 0; i < sequenceLength; i++)
297         {
298             links.Delete(sequence[i]);
299         }
300     }
301
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     var sequence = new[]
315     {
316         e1, e2, e1, e2 // mama / papa
317     };
318
319     var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
320
321     var balancedVariant = balancedVariantConverter.Convert(sequence);
322
323     // 1: [1]
324     // 2: [2]
325     // 3: [1,2]
326     // 4: [1,2,1,2]
327
328     var doublet = links.GetSource(balancedVariant);
329
330     var matchedSequences1 = sequences.MatchPattern(e2, e1, zeroOrMany);
331
332     Assert.True(matchedSequences1.Count == 0);
333
334     var matchedSequences2 = sequences.MatchPattern(zeroOrMany, e2, e1);
335
336     Assert.True(matchedSequences2.Count == 0);
337
338     var matchedSequences3 = sequences.MatchPattern(e1, zeroOrMany, e1);
339
340     Assert.True(matchedSequences3.Count == 0);
341
342     var matchedSequences4 = sequences.MatchPattern(e1, zeroOrMany, e2);
343
344     Assert.Contains(doublet, matchedSequences4);
345     Assert.Contains(balancedVariant, matchedSequences4);
346
347     for (var i = 0; i < sequence.Length; i++)
348     {
349         links.Delete(sequence[i]);
350     }
351 }
352
353 [Fact]
354 public static void IndexTest()
355 {
356     using (var scope = new TempLinksTestScope(new SequencesOptions<ulong> { UseIndex =
357         ↪ 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/%
380 ↪ 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
381 ↪ %D0%B8%D0%BD%D0%B0%D0%BB%D0%BE%D1%81%D1%8C.md</summary>
382 private static readonly string _exampleText =
383     @"([english
384     ↪ version] (https://github.com/Konard/LinksPlatform/wiki/About-the-beginning))

```

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

385 [![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)

386

387 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?

388

389 [![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)

390

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

392

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?
↳ Грань? 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-anim
    ↳  ation-500.gif
    ↳  "анимация")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/intro
    ↳  -animation-500.gif)";
434
435      private static readonly string _exampleLoremIpsumText =
436          @"Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor
    ↳  incididunt ut labore et dolore magna aliqua.
437  Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo
    ↳  consequat.";
438
439      [Fact]
440      public static void CompressionTest()
441      {
442          using (var scope = new TempLinksTestScope(useSequences: true))
443          {
444              var links = scope.Links;
445              var sequences = scope.Sequences;
446
447              var e1 = links.Create();
448              var e2 = links.Create();
449
450              var sequence = new[]
451              {
452                  e1, e2, e1, e2 // mama / papa / template [(m/p), a] { [1] [2] [1] [2] }
453              };
454
455              var balancedVariantConverter = new BalancedVariantConverter<ulong>(links.Unsync);
456              var totalSequenceSymbolFrequencyCounter = new
    ↳  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 Assert.True(links.GetSource(links.GetSource(compressedVariant)) == sequence[0]);
467 Assert.True(links.GetTarget(links.GetSource(compressedVariant)) == sequence[1]);
468 Assert.True(links.GetSource(links.GetTarget(compressedVariant)) == sequence[2]);
469 Assert.True(links.GetTarget(links.GetTarget(compressedVariant)) == sequence[3]);
470
471
472 var source = _constants.SourcePart;
473 var target = _constants.TargetPart;
474
475 Assert.True(links.GetByKeys(compressedVariant, source, source) == sequence[0]);
476 Assert.True(links.GetByKeys(compressedVariant, source, target) == sequence[1]);
477 Assert.True(links.GetByKeys(compressedVariant, target, source) == sequence[2]);
478 Assert.True(links.GetByKeys(compressedVariant, target, target) == sequence[3]);
479
480 // 4 - length of sequence
481 Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 0)
482     ↳ == sequence[0]);
483 Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 1)
484     ↳ == sequence[1]);
485 Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 2)
486     ↳ == sequence[2]);
487 Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 3)
488     ↳ == sequence[3]);
489
490 }
491
492 [Fact]
493 public static void CompressionEfficiencyTest()
494 {
495     var strings = _exampleLoremIpsumText.Split(new[] { '\n', '\r' },
496         ↳ StringSplitOptions.RemoveEmptyEntries);
497     var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
498     var totalCharacters = arrays.Select(x => x.Length).Sum();
499
500     using (var scope1 = new TempLinksTestScope(useSequences: true))
501     using (var scope2 = new TempLinksTestScope(useSequences: true))
502     using (var scope3 = new TempLinksTestScope(useSequences: true))
503     {
504         scope1.Links.Unsync.UseUnicode();
505         scope2.Links.Unsync.UseUnicode();
506         scope3.Links.Unsync.UseUnicode();
507
508         var balancedVariantConverter1 = new
509             ↳ BalancedVariantConverter<ulong>(scope1.Links.Unsync);
510         var totalSequenceSymbolFrequencyCounter = new
511             ↳ TotalSequenceSymbolFrequencyCounter<ulong>(scope1.Links.Unsync);
512         var linkFrequenciesCache1 = new LinkFrequenciesCache<ulong>(scope1.Links.Unsync,
513             ↳ totalSequenceSymbolFrequencyCounter);
514         var compressor1 = new CompressingConverter<ulong>(scope1.Links.Unsync,
515             ↳ balancedVariantConverter1, linkFrequenciesCache1,
516             ↳ doInitialFrequenciesIncrement: false);
517
518         //var compressor2 = scope2.Sequences;
519         var compressor3 = scope3.Sequences;
520
521         var constants = Default<LinksConstants<ulong>>.Instance;
522
523         var sequences = compressor3;
524         //var meaningRoot = links.CreatePoint();
525         //var unaryOne = links.CreateAndUpdate(meaningRoot, constants.Itself);
526         //var frequencyMarker = links.CreateAndUpdate(meaningRoot, constants.Itself);
527         //var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot,
528             ↳ constants.Itself);
529
530         //var unaryNumberToAddressConverter = new
531             ↳ UnaryNumberToAddressAddOperationConverter<ulong>(links, unaryOne);
532         //var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links,
533             ↳ unaryOne);
534         //var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
535             ↳ frequencyMarker, unaryOne, unaryNumberIncrementer);
536         //var frequencyPropertyOperator = new FrequencyPropertyOperator<ulong>(links,
537             ↳ frequencyPropertyMarker, frequencyMarker);
538         //var linkFrequencyIncrementer = new LinkFrequencyIncrementer<ulong>(links,
539             ↳ frequencyPropertyOperator, frequencyIncrementer);
540         //var linkToItsFrequencyNumberConverter = new
541             ↳ LinkToItsFrequencyNumberConveter<ulong>(links, frequencyPropertyOperator,
542             ↳ unaryNumberToAddressConverter);

```

```

526 var linkFrequenciesCache3 = new LinkFrequenciesCache<ulong>(scope3.Links.Unsync,
527     ↳ totalSequenceSymbolFrequencyCounter);
528 var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache3);
529
530 var sequenceToItsLocalElementLevelsConverter = new
531     ↳ SequenceToItsLocalElementLevelsConverter<ulong>(scope3.Links.Unsync,
532     ↳ linkToItsFrequencyNumberConverter);
533 var optimalVariantConverter = new
534     ↳ OptimalVariantConverter<ulong>(scope3.Links.Unsync,
535     ↳ sequenceToItsLocalElementLevelsConverter);
536
537 var compressed1 = new ulong[arrays.Length];
538 var compressed2 = new ulong[arrays.Length];
539 var compressed3 = new ulong[arrays.Length];
540
541 var START = 0;
542 var END = arrays.Length;
543
544 //for (int i = START; i < END; i++)
545 //    linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
546
547 var initialCount1 = scope2.Links.Unsync.Count();
548
549 var sw1 = Stopwatch.StartNew();
550
551 for (int i = START; i < END; i++)
552 {
553     linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
554     compressed1[i] = compressor1.Convert(arrays[i]);
555 }
556
557 var elapsed1 = sw1.Elapsed;
558
559 var balancedVariantConverter2 = new
560     ↳ BalancedVariantConverter<ulong>(scope2.Links.Unsync);
561
562 var initialCount2 = scope2.Links.Unsync.Count();
563
564 var sw2 = Stopwatch.StartNew();
565
566 for (int i = START; i < END; i++)
567 {
568     compressed2[i] = balancedVariantConverter2.Convert(arrays[i]);
569 }
570
571 var elapsed2 = sw2.Elapsed;
572
573 for (int i = START; i < END; i++)
574 {
575     linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
576 }
577
578 var initialCount3 = scope3.Links.Unsync.Count();
579
580 var sw3 = Stopwatch.StartNew();
581
582 for (int i = START; i < END; i++)
583 {
584     //linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
585     compressed3[i] = optimalVariantConverter.Convert(arrays[i]);
586 }
587
588 var elapsed3 = sw3.Elapsed;
589
590 Console.WriteLine($"Compressor: {elapsed1}, Balanced variant: {elapsed2},
591     ↳ Optimal variant: {elapsed3}");
592
593 // Assert.True(elapsed1 > elapsed2);
594
595 // Checks
596 for (int i = START; i < END; i++)
597 {
598     var sequence1 = compressed1[i];
599     var sequence2 = compressed2[i];
600     var sequence3 = compressed3[i];
601
602     var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
603         ↳ scope1.Links.Unsync);

```

```

597         var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
598             ↳ scope2.Links.Unsync);
599
600         var decompress3 = UnicodeMap.FromSequenceLinkToString(sequence3,
601             ↳ scope3.Links.Unsync);
602
603         var structure1 = scope1.Links.Unsync.FormatStructure(sequence1, link =>
604             ↳ link.IsPartialPoint());
605         var structure2 = scope2.Links.Unsync.FormatStructure(sequence2, link =>
606             ↳ link.IsPartialPoint());
607         var structure3 = scope3.Links.Unsync.FormatStructure(sequence3, link =>
608             ↳ link.IsPartialPoint());
609
610         //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
611             ↳ arrays[i].Length > 3)
612             ↳ Assert.False(structure1 == structure2);
613         //if (sequence3 != Constants.Null && sequence2 != Constants.Null &&
614             ↳ arrays[i].Length > 3)
615             ↳ Assert.False(structure3 == structure2);
616
617         Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
618         Assert.True(strings[i] == decompress3 && decompress3 == decompress2);
619     }
620
621     Assert.True((int)(scope1.Links.Unsync.Count() - initialCount1) <
622         ↳ totalCharacters);
623     Assert.True((int)(scope2.Links.Unsync.Count() - initialCount2) <
624         ↳ totalCharacters);
625     Assert.True((int)(scope3.Links.Unsync.Count() - initialCount3) <
626         ↳ totalCharacters);
627
628     Console.WriteLine($"{(double)(scope1.Links.Unsync.Count() - initialCount1) /
629         ↳ totalCharacters} | {(double)(scope2.Links.Unsync.Count() - initialCount2) /
630         ↳ totalCharacters} | {(double)(scope3.Links.Unsync.Count() - initialCount3) /
631         ↳ totalCharacters}");
632
633     Assert.True(scope1.Links.Unsync.Count() - initialCount1 <
634         ↳ scope2.Links.Unsync.Count() - initialCount2);
635     Assert.True(scope3.Links.Unsync.Count() - initialCount3 <
636         ↳ scope2.Links.Unsync.Count() - initialCount2);
637
638     var duplicateProvider1 = new
639         ↳ DuplicateSegmentsProvider<ulong>(scope1.Links.Unsync, scope1.Sequences);
640     var duplicateProvider2 = new
641         ↳ DuplicateSegmentsProvider<ulong>(scope2.Links.Unsync, scope2.Sequences);
642     var duplicateProvider3 = new
643         ↳ DuplicateSegmentsProvider<ulong>(scope3.Links.Unsync, scope3.Sequences);
644
645     var duplicateCounter1 = new DuplicateSegmentsCounter<ulong>(duplicateProvider1);
646     var duplicateCounter2 = new DuplicateSegmentsCounter<ulong>(duplicateProvider2);
647     var duplicateCounter3 = new DuplicateSegmentsCounter<ulong>(duplicateProvider3);
648
649     var duplicates1 = duplicateCounter1.Count();
650
651     ConsoleHelpers.Debug("-----");
652
653     var duplicates2 = duplicateCounter2.Count();
654
655     ConsoleHelpers.Debug("-----");
656
657     var duplicates3 = duplicateCounter3.Count();
658
659     Console.WriteLine($"{duplicates1} | {duplicates2} | {duplicates3}");
660
661     linkFrequenciesCache1.ValidateFrequencies();
662     linkFrequenciesCache3.ValidateFrequencies();
663 }
664
665 [Fact]
666 public static void CompressionStabilityTest()
667 {
668     // TODO: Fix bug (do a separate test)
669     //const ulong minNumbers = 0;
670     //const ulong maxNumbers = 1000;
671
672     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))
        {
            scope1.Links.UseUnicode();
            scope2.Links.UseUnicode();
        }
        //var compressor1 = new Compressor(scope1.Links.Unsync, scope1.Sequences);
        var compressor1 = scope1.Sequences;
        var compressor2 = scope2.Sequences;
        var compressed1 = new ulong[arrays.Length];
        var compressed2 = new ulong[arrays.Length];
        var sw1 = Stopwatch.StartNew();
        var START = 0;
        var END = arrays.Length;
        // Collisions proved (cannot be solved by max doublet comparison, no stable rule)
        // Stability issue starts at 10001 or 11000
        //for (int i = START; i < END; i++)
        //{
        //    var first = compressor1.Compress(arrays[i]);
        //    var second = compressor1.Compress(arrays[i]);
        //    if (first == second)
        //        compressed1[i] = first;
        //    else
        //    {
        //        // TODO: Find a solution for this case
        //    }
        //}
        for (int i = START; i < END; i++)
        {
            var first = compressor1.Create(arrays[i].ShiftRight());
            var second = compressor1.Create(arrays[i].ShiftRight());
            if (first == second)
            {
                compressed1[i] = first;
            }
            else
            {
                // TODO: Find a solution for this case
            }
        }
        var elapsed1 = sw1.Elapsed;
        var balancedVariantConverter = new BalancedVariantConverter<ulong>(scope2.Links);
        var sw2 = Stopwatch.StartNew();
        for (int i = START; i < END; i++)
        {
            var first = balancedVariantConverter.Convert(arrays[i]);
            var second = balancedVariantConverter.Convert(arrays[i]);
            if (first == second)
            {
                compressed2[i] = first;
            }
        }
        var elapsed2 = sw2.Elapsed;

```



```

735 Debug.WriteLine($"Compressor: {elapsed1}, Balanced sequence creator:
736     ↳ {elapsed2}");
737
738 Assert.True(elapsed1 > elapsed2);
739
740 // Checks
741 for (int i = START; i < END; i++)
742 {
743     var sequence1 = compressed1[i];
744     var sequence2 = compressed2[i];
745
746     if (sequence1 != _constants.Null && sequence2 != _constants.Null)
747     {
748         var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
749             ↳ scope1.Links);
750
751         var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
752             ↳ scope2.Links);
753
754         //var structure1 = scope1.Links.FormatStructure(sequence1, link =>
755             ↳ link.IsPartialPoint());
756         //var structure2 = scope2.Links.FormatStructure(sequence2, link =>
757             ↳ link.IsPartialPoint());
758
759         //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
760             ↳ arrays[i].Length > 3)
761         //    Assert.False(structure1 == structure2);
762
763         Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
764     }
765 }
766
767 Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
768 Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
769
770 Debug.WriteLine($"{{(double)(scope1.Links.Count() - UnicodeMap.MapSize) /
771     ↳ totalCharacters}} | {{(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
772     ↳ totalCharacters}}");
773
774 Assert.True(scope1.Links.Count() <= scope2.Links.Count());
775
776 //compressor1.ValidateFrequencies();
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();

```

```

802     scope2.Links.UseUnicode();
803
804     var compressor1 = scope1.Sequences;
805     var compressor2 = scope2.Sequences;
806
807     var compressed1 = new ulong[arrays.Length];
808     var compressed2 = new ulong[arrays.Length];
809
810     var sw1 = Stopwatch.StartNew();
811
812     var START = 0;
813     var END = arrays.Length;
814
815     for (int i = START; i < END; i++)
816     {
817         compressed1[i] = compressor1.Create(arrays[i].ShiftRight());
818     }
819
820     var elapsed1 = sw1.Elapsed;
821
822     var balancedVariantConverter = new BalancedVariantConverter<ulong>(scope2.Links);
823
824     var sw2 = Stopwatch.StartNew();
825
826     for (int i = START; i < END; i++)
827     {
828         compressed2[i] = balancedVariantConverter.Convert(arrays[i]);
829     }
830
831     var elapsed2 = sw2.Elapsed;
832
833     Debug.WriteLine($"Compressor: {elapsed1}, Balanced sequence creator:
834         ↪ {elapsed2}");
835
836     Assert.True(elapsed1 > elapsed2);
837
838     // Checks
839     for (int i = START; i < END; i++)
840     {
841         var sequence1 = compressed1[i];
842         var sequence2 = compressed2[i];
843
844         if (sequence1 != _constants.Null && sequence2 != _constants.Null)
845         {
846             var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
847                 ↪ scope1.Links);
848
849             var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
850                 ↪ scope2.Links);
851
852             Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
853         }
854     }
855
856     Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
857     Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
858
859     Debug.WriteLine($"{{(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;

```

```

877     var sequences = scope.Sequences;
878
879     var sequence = new ulong[sequenceLength];
880     for (var i = 0; i < sequenceLength; i++)
881     {
882         sequence[i] = links.Create();
883     }
884
885     var createResults = sequences.CreateAllVariants2(sequence);
886
887     Global.Trash = createResults;
888
889     for (var i = 0; i < sequenceLength; i++)
890     {
891         links.Delete(sequence[i]);
892     }
893 }
894
895 [Fact]
896 public static void AllPossibleConnectionsTest()
897 {
898     const long sequenceLength = 5;
899
900     using (var scope = new TempLinksTestScope(useSequences: true))
901     {
902         var links = scope.Links;
903         var sequences = scope.Sequences;
904
905         var sequence = new ulong[sequenceLength];
906         for (var i = 0; i < sequenceLength; i++)
907         {
908             sequence[i] = links.Create();
909         }
910
911         var createResults = sequences.CreateAllVariants2(sequence);
912         var reverseResults = sequences.CreateAllVariants2(sequence.Reverse().ToArray());
913
914         for (var i = 0; i < 1; i++)
915         {
916             var sw1 = Stopwatch.StartNew();
917             var searchResults1 = sequences.GetAllConnections(sequence); sw1.Stop();
918
919             var sw2 = Stopwatch.StartNew();
920             var searchResults2 = sequences.GetAllConnections1(sequence); sw2.Stop();
921
922             var sw3 = Stopwatch.StartNew();
923             var searchResults3 = sequences.GetAllConnections2(sequence); sw3.Stop();
924
925             var sw4 = Stopwatch.StartNew();
926             var searchResults4 = sequences.GetAllConnections3(sequence); sw4.Stop();
927
928             Global.Trash = searchResults3;
929             Global.Trash = searchResults4; //-V3008
930
931             var intersection1 = createResults.Intersect(searchResults1).ToList();
932             Assert.True(intersection1.Count == createResults.Length);
933
934             var intersection2 = reverseResults.Intersect(searchResults1).ToList();
935             Assert.True(intersection2.Count == reverseResults.Length);
936
937             var intersection0 = searchResults1.Intersect(searchResults2).ToList();
938             Assert.True(intersection0.Count == searchResults2.Count);
939
940             var intersection3 = searchResults2.Intersect(searchResults3).ToList();
941             Assert.True(intersection3.Count == searchResults3.Count);
942
943             var intersection4 = searchResults3.Intersect(searchResults4).ToList();
944             Assert.True(intersection4.Count == searchResults4.Count);
945         }
946
947         for (var i = 0; i < sequenceLength; i++)
948         {
949             links.Delete(sequence[i]);
950         }
951     }
952 }
953
954 [Fact(Skip = "Correct implementation is pending")]
955 public static void CalculateAllUsagesTest()
956

```

```

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 }

```

1.183 ./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));

```

```

34         Using<uint>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Test
    ↪ MultipleRandomCreationsAndDeletions(100));
35     Using<ulong>(links => links.DecorateWithAutomaticUniquenessAndUsagesResolution().Tes
    ↪ tMultipleRandomCreationsAndDeletions(100));
36 }
37
38 private static void Using<TLink>(Action<ILinks<TLink>> action)
39 {
40     using (var dataMemory = new HeapResizableDirectMemory())
41     using (var indexMemory = new HeapResizableDirectMemory())
42     using (var memory = new SplitMemoryLinks<TLink>(dataMemory, indexMemory))
43     {
44         action(memory);
45     }
46 }
47
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,
    ↪ SplitMemoryLinks<TLink>.DefaultLinksSizeStep, constants))
54     {
55         action(memory);
56     }
57 }
58 }
59 }

```

1.184 ./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().TestMultip
    ↪ leRandomCreationsAndDeletions(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,
    ↪ UInt32SplitMemoryLinks.DefaultLinksSizeStep, constants))
45         {

```

```

46         action(memory);
47     }
48 }
49 }
50 }

```

1.185 ./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     }

```

1.186 ./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
    ↪ useLog = false) : this(new SequencesOptions<ulong>(), deleteFiles, useSequences,
    ↪ useLog) { }
21
22 public TempLinksTestScope(SequencesOptions<ulong> sequencesOptions, bool deleteFiles =
    ↪ true, bool useSequences = false, bool useLog = false)
23 {
24     _deleteFiles = deleteFiles;
25     TempFilename = Path.GetTempFileName();
26     TempTransactionLogFilename = Path.GetTempFileName();
27     //var coreMemoryAdapter = new UInt64UnitedMemoryLinks(TempFilename);
28     var coreMemoryAdapter = new UInt64SplitMemoryLinks(new
        ↪ FileMappedResizableDirectMemory(TempFilename), new
        ↪ FileMappedResizableDirectMemory(Path.ChangeExtension(TempFilename, "indexes")),
        ↪ UInt64SplitMemoryLinks.DefaultLinksSizeStep, new LinksConstants<ulong>(),
        ↪ Memory.IndexTreeType.Default, useLinkedList: true);
29     MemoryAdapter = useLog ? (ILinks<ulong>)new
        ↪ UInt64LinksTransactionsLayer(coreMemoryAdapter, TempTransactionLogFilename) :
        ↪ coreMemoryAdapter;
30     Links = new SynchronizedLinks<ulong>(new UInt64Links(MemoryAdapter));
31     if (useSequences)
32     {
33         Sequences = new Sequences.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 }

```

1.187 ./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,
→ uInt64ToAddressConverter.Convert(linksCount)) > 0)
179                 {
180                     created++;
181                 }
182             }
183             else
184             {
185                 links.Create();
186                 created++;

```

```

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

```

1.188 ./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
44         [Fact]
45         public static void CascadeUpdateTest()
46         {
47             var itself = _constants.Itself;
48             using (var scope = new TempLinksTestScope(useLog: true))
49             {
50                 var links = scope.Links;
51
52                 var l1 = links.Create();
53                 var l2 = links.Create();
54
55                 l2 = links.Update(l2, l2, l1, l2);
56
57                 links.CreateAndUpdate(l2, itself);
58                 links.CreateAndUpdate(l2, itself);
59
60                 l2 = links.Update(l2, l1);
61             }
62         }
63     }
64 }

```

```

60         links.Delete(l2);
61
62         Global.Trash = links.Count();
63
64         links.Unsync.DisposeIfPossible(); // Close links to access log
65
66         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(scope
        ↪ e.TempTransactionLogFilename);
67     }
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_
138         ↪ tion>(scope.TempTransactionLogFilename);
139
140         l2 = links.Update(l2, l1);
141
142         links.Delete(l2);
143
144         ExceptionThrower();
145
146         transaction.Commit();
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_
156     ↪ astScope.TempTransactionLogFilename);
157
158     Assert.True(transitions.Length == 1 && transitions[0].Before.IsNull() &&
159     ↪ transitions[0].After.IsNull());
160
161     lastScope.DeleteFiles();
162 }
163 }
164 [Fact]
165 public static void TransactionUserCodeErrorSomeDataSavedTest()
166 {
167     // User Code Error (Autoreverted), some data saved
168     var itself = _constants.Itself;
169
170     TempLinksTestScope lastScope = null;
171     try
172     {
173         ulong l1;
174         ulong l2;
175
176         using (var scope = new TempLinksTestScope(useLog: true))
177         {
178             var links = scope.Links;
179             l1 = links.CreateAndUpdate(itself, itself);
180             l2 = links.CreateAndUpdate(itself, itself);
181
182             l2 = links.Update(l2, l2, l1, l2);
183
184             links.CreateAndUpdate(l2, itself);
185             links.CreateAndUpdate(l2, itself);
186
187             links.Unsync.DisposeIfPossible();
188
189             Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(
190             ↪ scope.TempTransactionLogFilename);
191         }
192
193         using (var scope = lastScope = new TempLinksTestScope(deleteFiles: false,
194         ↪ useLog: true))
195         {
196             var links = scope.Links;
197             var transactionsLayer = (UInt64LinksTransactionsLayer)links.Unsync;
198             using (var transaction = transactionsLayer.BeginTransaction())
199             {
200                 l2 = links.Update(l2, l1);
201
202                 links.Delete(l2);
203
204                 ExceptionThrower();
205
206                 transaction.Commit();
207             }
208
209             Global.Trash = links.Count();
210         }
211     }
212 }

```

```

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     File.Delete(tempDatabaseFilename);
355     File.Delete(tempTransactionLogFilename);
356 }
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.CheckPathExistence(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 {

```

```

426     try
427     {
428         links.TestLinksInSteps();
429     }
430     catch (Exception ex)
431     {
432         ex.WriteToConsole();
433     }
434
435     return;
436
437     try
438     {
439         //ThreadPool.SetMaxThreads(2, 2);
440
441         // Запускаем все тесты дважды, чтобы первоначальная инициализация не повлияла на
↪ 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.Write("\rD {0}/{1}", i + 1, loops);
508     }
509
510     ConsoleHelpers.Debug();
511
512     ConsoleHelpers.Debug("C S D");
513
514     for (int i = 0; i < loops; i++)
515     {
516         ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i],
↵ searchMeasurements[i], deletionMeasurements[i]);
517     }
518
519     ConsoleHelpers.Debug("C S D (no overhead)");
520
521     for (int i = 0; i < loops; i++)
522     {
523         ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i] - stepLoopOverhead,
↵ searchMeasurements[i] - stepLoopOverhead, deletionMeasurements[i] - stepLoopOverhead);
524     }
525
526     ConsoleHelpers.Debug("All tests done. Total links left in database: {0}.",
↵ links.Total);
527 }
528
529 ↵ private static void CreatePoints(this Platform.Links.Data.Core.Doublets.Links links, long
amountToCreate)
530 {
531     for (long i = 0; i < amountToCreate; i++)
532         links.Create(0, 0);
533 }
534
535 private static TimeSpan GetBaseRandomLoopOverhead(long loops)
536 {
537     return Measure(() =>
538     {
539         ulong maxValue = RandomHelpers.DefaultFactory.NextUInt64();
540         ulong result = 0;
541         for (long i = 0; i < loops; i++)
542         {
543             var source = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
544             var target = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
545
546             result += maxValue + source + target;
547         }
548         Global.Trash = result;
549     });
550 }
551 */
552
553 [Fact(Skip = "performance test")]
554 public static void GetSourceTest()
555 {
556     using (var scope = new TempLinksTestScope())
557     {
558         var links = scope.Links;
559         ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations.",
↵ Iterations);
560
561         ulong counter = 0;
562
563         //var firstLink = links.First();
564         // Создаём одну связь, из которой будет производить считывание
565         var firstLink = links.Create();
566
567         var sw = Stopwatch.StartNew();
568
569         // Тестируем саму функцию
570         for (ulong i = 0; i < Iterations; i++)
571         {
572             counter += links.GetSource(firstLink);
573         }
574
575         var elapsedTime = sw.Elapsed;
576

```

```

577     var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
578
579     // Удаляем связь, из которой производилось считывание
580     links.Delete(firstLink);
581
582     ConsoleHelpers.Debug(
583         "{0} Iterations of GetSource function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
        Iterations, elapsedTime, (long)iterationsPerSecond, counter);
584     }
585 }
586
587 [Fact(Skip = "performance test")]
588 public static void GetSourceInParallel()
589 {
590     using (var scope = new TempLinksTestScope())
591     {
592         var links = scope.Links;
593         ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations in
        ↳ parallel.", Iterations);
594
595         long counter = 0;
596
597         //var firstLink = links.First();
598         var firstLink = links.Create();
599
600         var sw = Stopwatch.StartNew();
601
602         // Тестируем саму функцию
603         Parallel.For(0, Iterations, x =>
604         {
605             Interlocked.Add(ref counter, (long)links.GetSource(firstLink));
606             //Interlocked.Increment(ref counter);
607         });
608
609         var elapsedTime = sw.Elapsed;
610
611         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
612
613         links.Delete(firstLink);
614
615         ConsoleHelpers.Debug(
616             "{0} Iterations of GetSource function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
        Iterations, elapsedTime, (long)iterationsPerSecond, counter);
617     }
618 }
619
620 [Fact(Skip = "performance test")]
621 public static void TestGetTarget()
622 {
623     using (var scope = new TempLinksTestScope())
624     {
625         var links = scope.Links;
626         ConsoleHelpers.Debug("Testing GetTarget function with {0} Iterations.",
        ↳ Iterations);
627
628         ulong counter = 0;
629
630         //var firstLink = links.First();
631         var firstLink = links.Create();
632
633         var sw = Stopwatch.StartNew();
634
635         for (ulong i = 0; i < Iterations; i++)
636         {
637             counter += links.GetTarget(firstLink);
638         }
639
640         var elapsedTime = sw.Elapsed;
641
642         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
643
644         links.Delete(firstLink);
645
646         ConsoleHelpers.Debug(
647             "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
        Iterations, elapsedTime, (long)iterationsPerSecond, counter);
648     }
649 }
650

```

```

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}",
683             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
684     }
685 }
686
687 // TODO: Заполнить базу данных перед тестом
688 /*
689 [Fact]
690 public void TestRandomSearchFixed()
691 {
692     var tempFilename = Path.GetTempFileName();
693
694     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
695 ↳ DefaultLinksSizeStep))
696     {
697         long iterations = 64 * 1024 * 1024 /
698 ↳ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
699
700         ulong counter = 0;
701         var maxLink = links.Total;
702
703         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.", iterations);
704
705         var sw = Stopwatch.StartNew();
706
707         for (var i = iterations; i > 0; i--)
708         {
709             var source =
710 ↳ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
711             var target =
712 ↳ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
713
714             counter += links.Search(source, target);
715         }
716
717         var elapsedTime = sw.Elapsed;
718
719         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
720
721         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
722 ↳ Iterations per second), c: {3}", iterations, elapsedTime, (long)iterationsPerSecond,
723 ↳ counter);
724     }
725
726     File.Delete(tempFilename);
727 }*/

```

```

722 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
723 public static void TestRandomSearchAll()
724 {
725     using (var scope = new TempLinksTestScope())
726     {
727         var links = scope.Links;
728         ulong counter = 0;
729
730         var maxLink = links.Count();
731
732         var iterations = links.Count();
733
734         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.",
735             ↪ links.Count());
736
737         var sw = Stopwatch.StartNew();
738
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
750         var elapsedTime = sw.Elapsed;
751
752         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
753
754         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
755             ↪ Iterations per second), c: {3}",
756             iterations, elapsedTime, (long)iterationsPerSecond, counter);
757     }
758
759 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
760 public static void TestEach()
761 {
762     using (var scope = new TempLinksTestScope())
763     {
764         var links = scope.Links;
765
766         var counter = new Counter<IList<ulong>, ulong>(links.Constants.Continue);
767
768         ConsoleHelpers.Debug("Testing Each function.");
769
770         var sw = Stopwatch.StartNew();
771
772         links.Each(counter.IncrementAndReturnTrue);
773
774         var elapsedTime = sw.Elapsed;
775
776         var linksPerSecond = counter.Count / elapsedTime.TotalSeconds;
777
778         ConsoleHelpers.Debug("{0} Iterations of Each's handler function done in {1} ({2}
779             ↪ links per second)",
780             counter, elapsedTime, (long)linksPerSecond);
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)

```

```

797         //{
798         //     counter++;
799         //}
800
801         var elapsedTime = sw.Elapsed;
802
803         var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
804
805         ConsoleHelpers.Debug("{0} Iterations of Foreach's handler block done in {1} ({2}
↪ links per second)", counter, elapsedTime, (long)linksPerSecond);
806     }
807
808     File.Delete(tempFilename);
809 }
810 */
811
812 /*
813 [Fact]
814 public static void TestParallelForeach()
815 {
816     var tempFilename = Path.GetTempFileName();
817
818     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
↪ DefaultLinksSizeStep))
819     {
820
821         long counter = 0;
822
823         ConsoleHelpers.Debug("Testing parallel foreach through links.");
824
825         var sw = Stopwatch.StartNew();
826
827         //Parallel.ForEach((IEnumerable<ulong>)links, x =>
828         //{
829         //     Interlocked.Increment(ref counter);
830         //});
831
832         var elapsedTime = sw.Elapsed;
833
834         var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
835
836         ConsoleHelpers.Debug("{0} Iterations of Parallel Foreach's handler block done in
↪ {1} ({2} links per second)", counter, elapsedTime, (long)linksPerSecond);
837     }
838
839     File.Delete(tempFilename);
840 }
841 */
842
843 [Fact(Skip = "performance test")]
844 public static void Create64BillionLinks()
845 {
846     using (var scope = new TempLinksTestScope())
847     {
848         var links = scope.Links;
849         var linksBeforeTest = links.Count();
850
851         long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
852
853         ConsoleHelpers.Debug("Creating {0} links.", linksToCreate);
854
855         var elapsedTime = Performance.Measure(() =>
856         {
857             for (long i = 0; i < linksToCreate; i++)
858             {
859                 links.Create();
860             }
861         });
862
863         var linksCreated = links.Count() - linksBeforeTest;
864         var linksPerSecond = linksCreated / elapsedTime.TotalSeconds;
865
866         ConsoleHelpers.Debug("Current links count: {0}.", links.Count());
867
868         ConsoleHelpers.Debug("{0} links created in {1} ({2} links per second)",
↪ linksCreated, elapsedTime,
869             (long)linksPerSecond);
870     }
871 }
872

```

```

873 [Fact(Skip = "performance test")]
874 public static void Create64BillionLinksInParallel()
875 {
876     using (var scope = new TempLinksTestScope())
877     {
878         var links = scope.Links;
879         var linksBeforeTest = links.Count();
880
881         var sw = Stopwatch.StartNew();
882
883         long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
884
885         ConsoleHelpers.Debug("Creating {0} links in parallel.", linksToCreate);
886
887         Parallel.For(0, linksToCreate, x => links.Create());
888
889         var elapsedTime = sw.Elapsed;
890
891         var linksCreated = links.Count() - linksBeforeTest;
892         var linksPerSecond = linksCreated / elapsedTime.TotalSeconds;
893
894         ConsoleHelpers.Debug("{0} links created in {1} ({2} links per second)",
895             ↪ linksCreated, elapsedTime,
896             (long)linksPerSecond);
897     }
898 }
899 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
900 public static void TestDeletionOfAllLinks()
901 {
902     using (var scope = new TempLinksTestScope())
903     {
904         var links = scope.Links;
905         var linksBeforeTest = links.Count();
906
907         ConsoleHelpers.Debug("Deleting all links");
908
909         var elapsedTime = Performance.Measure(links.DeleteAll);
910
911         var linksDeleted = linksBeforeTest - links.Count();
912         var linksPerSecond = linksDeleted / elapsedTime.TotalSeconds;
913
914         ConsoleHelpers.Debug("{0} links deleted in {1} ({2} links per second)",
915             ↪ linksDeleted, elapsedTime,
916             (long)linksPerSecond);
917     }
918 }
919 #endregion
920 }
921 }

```

1.189 ./csharp/Platform.Data.Doublets.Tests/UInt64LinksExtensionsTests.cs

```

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

```

```

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

```

1.190 ./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
                    ↪ PowerOf2ToUnaryNumberConverter<ulong>(links, one);
19                 var toUnaryNumberConverter = new AddressToUnaryNumberConverter<ulong>(links,
                    ↪ powerOf2ToUnaryNumberConverter);
20                 var random = new System.Random(0);
21                 ulong[] numbers = new ulong[N];
22                 ulong[] unaryNumbers = new ulong[N];
23                 for (int i = 0; i < N; i++)
24                 {
25                     numbers[i] = random.NextUInt64();
26                     unaryNumbers[i] = toUnaryNumberConverter.Convert(numbers[i]);
27                 }
28                 var fromUnaryNumberConverterUsingOrOperation = new
                    ↪ UnaryNumberToAddressOrOperationConverter<ulong>(links,
                    ↪ powerOf2ToUnaryNumberConverter);
29                 var fromUnaryNumberConverterUsingAddOperation = new
                    ↪ UnaryNumberToAddressAddOperationConverter<ulong>(links, one);
30                 for (int i = 0; i < N; i++)
31                 {
32                     Assert.Equal(numbers[i],
                        ↪ fromUnaryNumberConverterUsingOrOperation.Convert(unaryNumbers[i]));
33                     Assert.Equal(numbers[i],
                        ↪ fromUnaryNumberConverterUsingAddOperation.Convert(unaryNumbers[i]));
34                 }
35             }
36         }
37     }
38 }

```

1.191 ./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())
77             {
78                 var links = scope.Links;
79
80                 var itself = links.Constants.Itself;
81
82                 var meaningRoot = links.CreatePoint();
83                 var unaryOne = links.CreateAndUpdate(meaningRoot, itself);
84                 var unicodeSymbolMarker = links.CreateAndUpdate(meaningRoot, itself);
85                 var unicodeSequenceMarker = links.CreateAndUpdate(meaningRoot, itself);
86                 var frequencyMarker = links.CreateAndUpdate(meaningRoot, itself);
87                 var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot, itself);
88
89                 var powerOf2ToUnaryNumberConverter = new
90                     ↪ PowerOf2ToUnaryNumberConverter<ulong>(links, unaryOne);

```



```

78     var addressToUnaryNumberConverter = new
       ↳ AddressToUnaryNumberConverter<ulong>(links, powerOf2ToUnaryNumberConverter);
79     var charToUnicodeSymbolConverter = new
       ↳ CharToUnicodeSymbolConverter<ulong>(links, addressToUnaryNumberConverter,
       ↳ unicodeSymbolMarker);
80
81     var unaryNumberToAddressConverter = new
       ↳ UnaryNumberToAddressOrOperationConverter<ulong>(links,
       ↳ powerOf2ToUnaryNumberConverter);
82     var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links, unaryOne);
83     var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
       ↳ frequencyMarker, unaryOne, unaryNumberIncrementer);
84     var frequencyPropertyOperator = new PropertyOperator<ulong>(links,
       ↳ frequencyPropertyMarker, frequencyMarker);
85     var index = new FrequencyIncrementingSequenceIndex<ulong>(links,
       ↳ frequencyPropertyOperator, frequencyIncrementer);
86     var linkToItsFrequencyNumberConverter = new
       ↳ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
       ↳ unaryNumberToAddressConverter);
87     var sequenceToItsLocalElementLevelsConverter = new
       ↳ SequenceToItsLocalElementLevelsConverter<ulong>(links,
       ↳ linkToItsFrequencyNumberConverter);
88     var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
       ↳ sequenceToItsLocalElementLevelsConverter);
89
90     var stringToUnicodeSequenceConverter = new
       ↳ StringToUnicodeSequenceConverter<ulong>(links, charToUnicodeSymbolConverter,
       ↳ index, optimalVariantConverter, unicodeSequenceMarker);
91
92     var originalString = "Hello";
93
94     var unicodeSequenceLink =
       ↳ stringToUnicodeSequenceConverter.Convert(originalString);
95
96     var unicodeSymbolCriterionMatcher = new TargetMatcher<ulong>(links,
       ↳ unicodeSymbolMarker);
97     var unicodeSymbolToCharConverter = new
       ↳ UnicodeSymbolToCharConverter<ulong>(links, unaryNumberToAddressConverter,
       ↳ unicodeSymbolCriterionMatcher);
98
99     var unicodeSequenceCriterionMatcher = new TargetMatcher<ulong>(links,
       ↳ unicodeSequenceMarker);
100
101     var sequenceWalker = new LeveledSequenceWalker<ulong>(links,
       ↳ unicodeSymbolCriterionMatcher.IsMatched);
102
103     var unicodeSequenceToStringConverter = new
       ↳ UnicodeSequenceToStringConverter<ulong>(links,
       ↳ unicodeSequenceCriterionMatcher, sequenceWalker,
       ↳ unicodeSymbolToCharConverter);
104
105     var resultingString =
       ↳ unicodeSequenceToStringConverter.Convert(unicodeSequenceLink);
106
107     Assert.Equal(originalString, resultingString);
108 }
109 }
110 }
111 }

```

1.192 ./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 }

```

```

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 }

```

1.193 ./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     }

```

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