

## LinksPlatform's Platform.Numbers Class Library

### 1.1 ./Platform.Numbers/Arithmetic.cs

```
1 using System;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Numbers
7 {
8     public static class Arithmetic
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public static T Add<T>(T x, T y) => Arithmetic<T>.Add(x, y);
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public static T Subtract<T>(T x, T y) => Arithmetic<T>.Subtract(x, y);
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         [Obsolete]
18         public static T Subtract<T>(Integer<T> x, Integer<T> y) => Arithmetic<T>.Subtract(x, y);
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public static T Increment<T>(T x) => Arithmetic<T>.Increment(x);
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public static T Decrement<T>(T x) => Arithmetic<T>.Decrement(x);
25     }
26 }
```

### 1.2 ./Platform.Numbers/ArithmeticExtensions.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.Numbers
6 {
7     public static class ArithmeticExtensions
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public static T Decrement<T>(this ref T x) where T : struct => x =
11            ↪ Arithmetic<T>.Decrement(x);
12
13        [MethodImpl(MethodImplOptions.AggressiveInlining)]
14        public static T Increment<T>(this ref T x) where T : struct => x =
15            ↪ Arithmetic<T>.Increment(x);
16    }
17 }
```

### 1.3 ./Platform.Numbers/Arithmetic[T].cs

```
1 using System;
2 using System.Runtime.CompilerServices;
3 using Platform.Exceptions;
4 using Platform.Reflection;
5
6 // ReSharper disable StaticFieldInGenericType
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Numbers
10 {
11     public static class Arithmetic<T>
12     {
13         public static readonly Func<T, T, T> Add = CompileAddDelegate();
14         public static readonly Func<T, T, T> Subtract = CompileSubtractDelegate();
15         public static readonly Func<T, T> Increment = CompileIncrementDelegate();
16         public static readonly Func<T, T> Decrement = CompileDecrementDelegate();
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         private static Func<T, T, T> CompileAddDelegate()
20         {
21             return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
22             {
23                 Ensure.Always.IsNumeric<T>();
24                 emitter.LoadArguments(0, 1);
25                 emitter.Add();
26                 emitter.Return();
27             });
28         }
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
```

```

31 private static Func<T, T, T> CompileSubtractDelegate()
32 {
33     return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
34     {
35         Ensure.Always.IsNumeric<T>();
36         emitter.LoadArguments(0, 1);
37         emitter.Subtract();
38         emitter.Return();
39     });
40 }
41
42 [MethodImpl(MethodImplOptions.AggressiveInlining)]
43 private static Func<T, T> CompileIncrementDelegate()
44 {
45     return DelegateHelpers.Compile<Func<T, T>>(emitter =>
46     {
47         Ensure.Always.IsNumeric<T>();
48         emitter.LoadArgument(0);
49         emitter.Increment<T>();
50         emitter.Return();
51     });
52 }
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 private static Func<T, T> CompileDecrementDelegate()
56 {
57     return DelegateHelpers.Compile<Func<T, T>>(emitter =>
58     {
59         Ensure.Always.IsNumeric<T>();
60         emitter.LoadArgument(0);
61         emitter.Decrement<T>();
62         emitter.Return();
63     });
64 }
65 }
66 }

```

#### 1.4 ./Platform.Numbers/Bit.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.Numbers
6 {
7     public static class Bit
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public static long Count(long x)
11        {
12            long n = 0;
13            while (x != 0)
14            {
15                n++;
16                x &= x - 1;
17            }
18            return n;
19        }
20
21        [MethodImpl(MethodImplOptions.AggressiveInlining)]
22        public static int GetLowestPosition(ulong value)
23        {
24            if (value == 0)
25            {
26                return -1;
27            }
28            var position = 0;
29            while ((value & 1UL) == 0)
30            {
31                value >>= 1;
32                ++position;
33            }
34            return position;
35        }
36
37        [MethodImpl(MethodImplOptions.AggressiveInlining)]
38        public static T Not<T>(T x) => Bit<T>.Not(x);
39
40        [MethodImpl(MethodImplOptions.AggressiveInlining)]
41        public static T Or<T>(T x, T y) => Bit<T>.Or(x, y);

```

```

42
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     public static T And<T>(T x, T y) => Bit<T>.And(x, y);
45
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     public static T ShiftLeft<T>(T x, int y) => Bit<T>.ShiftLeft(x, y);
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     public static T ShiftRight<T>(T x, int y) => Bit<T>.ShiftRight(x, y);
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     public static T PartialWrite<T>(T target, T source, int shift, int limit) =>
54         ↪ Bit<T>.PartialWrite(target, source, shift, limit);
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     public static T PartialRead<T>(T target, int shift, int limit) =>
58         ↪ Bit<T>.PartialRead(target, shift, limit);
59 }

```

## 1.5 ./Platform.Numbers/BitExtensions.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.Numbers
6  {
7      public static class BitwiseExtensions
8      {
9          [MethodImpl(MethodImplOptions.AggressiveInlining)]
10         public static T Not<T>(this ref T target) where T : struct => target = Bit.Not(target);
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public static T PartialWrite<T>(this ref T target, T source, int shift, int limit) where
14             ↪ T : struct => target = Bit<T>.PartialWrite(target, source, shift, limit);
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public static T PartialRead<T>(this T target, int shift, int limit) =>
18             ↪ Bit<T>.PartialRead(target, shift, limit);
19     }
20 }

```

## 1.6 ./Platform.Numbers/Bit[T].cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Exceptions;
4  using Platform.Reflection;
5
6  // ReSharper disable StaticFieldInGenericType
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Numbers
10 {
11     public static class Bit<T>
12     {
13         public static readonly Func<T, T> Not = CompileNotDelegate();
14         public static readonly Func<T, T, T> Or = CompileOrDelegate();
15         public static readonly Func<T, T, T> And = CompileAndDelegate();
16         public static readonly Func<T, int, T> ShiftLeft = CompileShiftLeftDelegate();
17         public static readonly Func<T, int, T> ShiftRight = CompileShiftRightDelegate();
18         public static readonly Func<T, T, int, int, T> PartialWrite =
19             ↪ CompilePartialWriteDelegate();
20         public static readonly Func<T, int, int, T> PartialRead = CompilePartialReadDelegate();
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         private static Func<T, T> CompileNotDelegate()
24         {
25             return DelegateHelpers.Compile<Func<T, T>>(emitter =>
26             {
27                 Ensure.Always.IsNumeric<T>();
28                 emitter.LoadArguments(0);
29                 emitter.Not();
30                 emitter.Return();
31             });
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         private static Func<T, T, T> CompileOrDelegate()
35         {

```

```

36     return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
37     {
38         Ensure.Always.IsNumeric<T>();
39         emitter.LoadArguments(0, 1);
40         emitter.Or();
41         emitter.Return();
42     });
43 }
44
45 [MethodImpl(MethodImplOptions.AggressiveInlining)]
46 private static Func<T, T, T> CompileAndDelegate()
47 {
48     return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
49     {
50         Ensure.Always.IsNumeric<T>();
51         emitter.LoadArguments(0, 1);
52         emitter.And();
53         emitter.Return();
54     });
55 }
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 private static Func<T, int, T> CompileShiftLeftDelegate()
59 {
60     return DelegateHelpers.Compile<Func<T, int, T>>(emitter =>
61     {
62         Ensure.Always.IsNumeric<T>();
63         emitter.LoadArguments(0, 1);
64         emitter.ShiftLeft();
65         emitter.Return();
66     });
67 }
68
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 private static Func<T, int, T> CompileShiftRightDelegate()
71 {
72     return DelegateHelpers.Compile<Func<T, int, T>>(emitter =>
73     {
74         Ensure.Always.IsNumeric<T>();
75         emitter.LoadArguments(0, 1);
76         emitter.ShiftRight();
77         emitter.Return();
78     });
79 }
80
81 [MethodImpl(MethodImplOptions.AggressiveInlining)]
82 private static Func<T, T, int, int, T> CompilePartialWriteDelegate()
83 {
84     return DelegateHelpers.Compile<Func<T, T, int, int, T>>(emitter =>
85     {
86         Ensure.Always.IsNumeric<T>();
87         var constants = GetConstants();
88         var bitsNumber = constants.Item1;
89         var numberFilledWithOnes = constants.Item2;
90         ushort shiftArgument = 2;
91         ushort limitArgument = 3;
92         var checkLimit = emitter.DefineLabel();
93         var calculateSourceMask = emitter.DefineLabel();
94         // Check shift
95         emitter.LoadArgument(shiftArgument);
96         emitter.LoadConstant(0);
97         emitter.BranchIfGreaterOrEqual(checkLimit); // Skip fix
98         // Fix shift
99         emitter.LoadConstant(bitsNumber);
100        emitter.LoadArgument(shiftArgument);
101        emitter.Add();
102        emitter.StoreArgument(shiftArgument);
103        emitter.MarkLabel(checkLimit);
104        // Check limit
105        emitter.LoadArgument(limitArgument);
106        emitter.LoadConstant(0);
107        emitter.BranchIfGreaterOrEqual(calculateSourceMask); // Skip fix
108        // Fix limit
109        emitter.LoadConstant(bitsNumber);
110        emitter.LoadArgument(limitArgument);
111        emitter.Add();
112        emitter.StoreArgument(limitArgument);
113        emitter.MarkLabel(calculateSourceMask);

```

```

114     var sourceMask = emitter.DeclareLocal<T>();
115     var targetMask = emitter.DeclareLocal<T>();
116     emitter.LoadConstant(typeof(T), numberFilledWithOnes);
117     emitter.LoadArgument(limitArgument);
118     emitter.ShiftLeft();
119     emitter.Not();
120     emitter.LoadConstant(typeof(T), numberFilledWithOnes);
121     emitter.And();
122     emitter.StoreLocal(sourceMask);
123     emitter.LoadLocal(sourceMask);
124     emitter.LoadArgument(shiftArgument);
125     emitter.ShiftLeft();
126     emitter.Not();
127     emitter.StoreLocal(targetMask);
128     emitter.LoadArgument(0); // target
129     emitter.LoadLocal(targetMask);
130     emitter.And();
131     emitter.LoadArgument(1); // source
132     emitter.LoadLocal(sourceMask);
133     emitter.And();
134     emitter.LoadArgument(shiftArgument);
135     emitter.ShiftLeft();
136     emitter.Or();
137     emitter.Return();
138     });
139 }
140
141 [MethodImpl(MethodImplOptions.AggressiveInlining)]
142 private static Func<T, int, int, T> CompilePartialReadDelegate()
143 {
144     return DelegateHelpers.Compile<Func<T, int, int, T>>(emitter =>
145     {
146         Ensure.Always.IsNumeric<T>();
147         var constants = GetConstants();
148         var bitsNumber = constants.Item1;
149         var numberFilledWithOnes = constants.Item2;
150         ushort shiftArgument = 1;
151         ushort limitArgument = 2;
152         var checkLimit = emitter.DefineLabel();
153         var calculateSourceMask = emitter.DefineLabel();
154         // Check shift
155         emitter.LoadArgument(shiftArgument);
156         emitter.LoadConstant(0);
157         emitter.BranchIfGreaterOrEqual(checkLimit); // Skip fix
158         // Fix shift
159         emitter.LoadConstant(bitsNumber);
160         emitter.LoadArgument(shiftArgument);
161         emitter.Add();
162         emitter.StoreArgument(shiftArgument);
163         emitter.MarkLabel(checkLimit);
164         // Check limit
165         emitter.LoadArgument(limitArgument);
166         emitter.LoadConstant(0);
167         emitter.BranchIfGreaterOrEqual(calculateSourceMask); // Skip fix
168         // Fix limit
169         emitter.LoadConstant(bitsNumber);
170         emitter.LoadArgument(limitArgument);
171         emitter.Add();
172         emitter.StoreArgument(limitArgument);
173         emitter.MarkLabel(calculateSourceMask);
174         var sourceMask = emitter.DeclareLocal<T>();
175         var targetMask = emitter.DeclareLocal<T>();
176         emitter.LoadConstant(typeof(T), numberFilledWithOnes);
177         emitter.LoadArgument(limitArgument); // limit
178         emitter.ShiftLeft();
179         emitter.Not();
180         emitter.LoadConstant(typeof(T), numberFilledWithOnes);
181         emitter.And();
182         emitter.StoreLocal(sourceMask);
183         emitter.LoadLocal(sourceMask);
184         emitter.LoadArgument(shiftArgument);
185         emitter.ShiftLeft();
186         emitter.StoreLocal(targetMask);
187         emitter.LoadArgument(0); // target
188         emitter.LoadLocal(targetMask);
189         emitter.And();
190         emitter.LoadArgument(shiftArgument);
191         emitter.ShiftRight();

```

```

192         emitter.Return();
193     });
194 }
195
196 [MethodImpl(MethodImplOptions.AggressiveInlining)]
197 private static Tuple<int, T> GetConstants()
198 {
199     var type = typeof(T);
200     if (type == typeof(ulong))
201     {
202         return new Tuple<int, T>(64, (T)(object)ulong.MaxValue);
203     }
204     if (type == typeof(uint))
205     {
206         return new Tuple<int, T>(32, (T)(object)uint.MaxValue);
207     }
208     if (type == typeof(ushort))
209     {
210         return new Tuple<int, T>(16, (T)(object)ushort.MaxValue);
211     }
212     if (type == typeof(byte))
213     {
214         return new Tuple<int, T>(8, (T)(object)byte.MaxValue);
215     }
216     throw new NotSupportedException();
217 }
218 }
219 }

```

## 1.7 ./Platform.Numbers/Integer.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Numbers
7  {
8      [Obsolete]
9      public struct Integer : IEquatable<Integer>
10     {
11         public readonly ulong Value;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public Integer(ulong value) => Value = value;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public static implicit operator Integer(ulong integer) => new Integer(integer);
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         public static implicit operator Integer(long integer) => unchecked((ulong)integer);
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         public static implicit operator Integer(uint integer) => new Integer(integer);
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public static implicit operator Integer(int integer) => unchecked((ulong)integer);
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public static implicit operator Integer(ushort integer) => new Integer(integer);
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public static implicit operator Integer(short integer) => unchecked((ulong)integer);
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public static implicit operator Integer(byte integer) => new Integer(integer);
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public static implicit operator Integer(sbyte integer) => unchecked((ulong)integer);
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         public static implicit operator Integer(bool integer) => integer ? 1UL : 0UL;
42
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         public static implicit operator ulong(Integer integer) => integer.Value;
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         public static implicit operator long(Integer integer) => unchecked((long)integer.Value);
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         public static implicit operator uint(Integer integer) => unchecked((uint)integer.Value);

```

```

51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     public static implicit operator int(Integer integer) => unchecked((int)integer.Value);
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     public static implicit operator ushort(Integer integer) =>
56         ↪ unchecked((ushort)integer.Value);
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     public static implicit operator short(Integer integer) =>
60         ↪ unchecked((short)integer.Value);
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     public static implicit operator byte(Integer integer) => unchecked((byte)integer.Value);
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     public static implicit operator sbyte(Integer integer) =>
67         ↪ unchecked((sbyte)integer.Value);
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     public static implicit operator bool(Integer integer) => integer.Value != 0UL;
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     public bool Equals(Integer other) => Value == other.Value;
74
75     [MethodImpl(MethodImplOptions.AggressiveInlining)]
76     public override string ToString() => Value.ToString();
77 }

```

## 1.8 ./Platform.Numbers/Integer[T].cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using System.Collections.Generic;
4  using Platform.Exceptions;
5  using Platform.Reflection;
6
7  // ReSharper disable StaticFieldInGenericType
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9  #pragma warning disable RECS0108 // Warns about static fields in generic types
10
11 namespace Platform.Numbers
12 {
13     [Obsolete]
14     public struct Integer<T> : IEquatable<Integer<T>>
15     {
16         private static readonly EqualityComparer<T> _equalityComparer =
17             ↪ EqualityComparer<T>.Default;
18         private static readonly Func<ulong, Integer<T>> _create;
19
20         public static readonly T Zero;
21         public static readonly T One;
22         public static readonly T Two;
23
24         public readonly T Value;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         static Integer()
28         {
29             _create = CompileCreateDelegate();
30             try
31             {
32                 Zero = default;
33                 One = Arithmetic.Increment(Zero);
34                 Two = Arithmetic.Increment(One);
35             }
36             catch (Exception exception)
37             {
38                 exception.Ignore();
39             }
40
41             [MethodImpl(MethodImplOptions.AggressiveInlining)]
42             public Integer(T value) => Value = value;
43
44             [MethodImpl(MethodImplOptions.AggressiveInlining)]
45             public static implicit operator Integer(Integer<T> integer)
46             {
47                 if (typeof(T) == typeof(Integer))
48                 {

```

```

49         return (Integer)(object)integer.Value;
50     }
51     return Convert.ToUInt64(integer.Value);
52 }
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 public static implicit operator ulong(Integer<T> integer) => ((Integer)integer).Value;
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 public static implicit operator T(Integer<T> integer) => integer.Value;
59
60 [MethodImpl(MethodImplOptions.AggressiveInlining)]
61 public static implicit operator Integer<T>(T integer) => new Integer<T>(integer);
62
63 [MethodImpl(MethodImplOptions.AggressiveInlining)]
64 public static implicit operator Integer<T>(ulong integer) => _create(integer);
65
66 [MethodImpl(MethodImplOptions.AggressiveInlining)]
67 public static implicit operator Integer<T>(Integer integer) => _create(integer.Value);
68
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 public static implicit operator Integer<T>(long integer) => unchecked((ulong)integer);
71
72 [MethodImpl(MethodImplOptions.AggressiveInlining)]
73 public static implicit operator Integer<T>(uint integer) => new Integer(integer);
74
75 [MethodImpl(MethodImplOptions.AggressiveInlining)]
76 public static implicit operator Integer<T>(int integer) => unchecked((ulong)integer);
77
78 [MethodImpl(MethodImplOptions.AggressiveInlining)]
79 public static implicit operator Integer<T>(ushort integer) => new Integer(integer);
80
81 [MethodImpl(MethodImplOptions.AggressiveInlining)]
82 public static implicit operator Integer<T>(short integer) => unchecked((ulong)integer);
83
84 [MethodImpl(MethodImplOptions.AggressiveInlining)]
85 public static implicit operator Integer<T>(byte integer) => new Integer(integer);
86
87 [MethodImpl(MethodImplOptions.AggressiveInlining)]
88 public static implicit operator Integer<T>(sbyte integer) => unchecked((ulong)integer);
89
90 [MethodImpl(MethodImplOptions.AggressiveInlining)]
91 public static implicit operator Integer<T>(bool integer) => integer ? 1UL : 0UL;
92
93 [MethodImpl(MethodImplOptions.AggressiveInlining)]
94 public static implicit operator long(Integer<T> integer) =>
95     ↳ unchecked((long)(ulong)integer);
96
97 [MethodImpl(MethodImplOptions.AggressiveInlining)]
98 public static implicit operator uint(Integer<T> integer) =>
99     ↳ unchecked((uint)(ulong)integer);
100
101 [MethodImpl(MethodImplOptions.AggressiveInlining)]
102 public static implicit operator int(Integer<T> integer) =>
103     ↳ unchecked((int)(ulong)integer);
104
105 [MethodImpl(MethodImplOptions.AggressiveInlining)]
106 public static implicit operator ushort(Integer<T> integer) =>
107     ↳ unchecked((ushort)(ulong)integer);
108
109 [MethodImpl(MethodImplOptions.AggressiveInlining)]
110 public static implicit operator short(Integer<T> integer) =>
111     ↳ unchecked((short)(ulong)integer);
112
113 [MethodImpl(MethodImplOptions.AggressiveInlining)]
114 public static implicit operator byte(Integer<T> integer) =>
115     ↳ unchecked((byte)(ulong)integer);
116
117 [MethodImpl(MethodImplOptions.AggressiveInlining)]
118 public static implicit operator sbyte(Integer<T> integer) =>
119     ↳ unchecked((sbyte)(ulong)integer);
120
121 [MethodImpl(MethodImplOptions.AggressiveInlining)]
122 public static implicit operator bool(Integer<T> integer) => integer != 0UL;
123
124 [MethodImpl(MethodImplOptions.AggressiveInlining)]
125 public bool Equals(Integer<T> other) => _equalityComparer.Equals(Value, other.Value);
126
127 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```



```

121 public override string ToString() => Value.ToString();
122
123 [MethodImpl(MethodImplOptions.AggressiveInlining)]
124 private static Func<ulong, Integer<T>> CompileCreateDelegate()
125 {
126     return DelegateHelpers.Compile<Func<ulong, Integer<T>>>(emitter =>
127     {
128         if (typeof(T) != typeof(Integer))
129         {
130             Ensure.Always.CanBeNumeric<T>();
131         }
132         emitter.LoadArgument(0);
133         if (typeof(T) != typeof(ulong) && typeof(T) != typeof(Integer))
134         {
135             emitter.UncheckedConvert<ulong, T>();
136             //emitter.Call(typeof(To).GetMethod(typeof(T).Name, Types<ulong>.Array));
137         }
138         if (NumericType<T>.IsNullable)
139         {
140             emitter.NewObject(typeof(T), NumericType<T>.UnderlyingType);
141         }
142         if (typeof(T) == typeof(Integer))
143         {
144             emitter.NewObject(typeof(Integer), typeof(ulong));
145         }
146         emitter.NewObject(typeof(Integer<T>), typeof(T));
147         emitter.Return();
148     });
149 }
150 }
151 }

```

## 1.9 ./Platform.Numbers/Math.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.Numbers
6 {
7     /// <remarks>
8     /// Resizable array (FileMappedMemory) for values cache may be used. or cached oeis.org
9     /// </remarks>
10    public static class Math
11    {
12        /// <remarks>
13        /// <para>Source: https://oeis.org/A000142/list </para>
14        /// <para>Источник: https://oeis.org/A000142/list </para>
15        /// </remarks>
16        private static readonly double[] _factorials =
17        {
18            1D, 1D, 2D, 6D, 24D, 120D, 720D, 5040D, 40320D, 362880D, 3628800D, 39916800D,
19            479001600, 6227020800, 87178291200, 1307674368000D, 20922789888000D,
20            355687428096000D, 6402373705728000D, 121645100408832000D, 2432902008176640000D,
21            51090942171709440000D, 1124000727777607680000D
22        };
23
24        /// <remarks>
25        /// <para>Source: https://oeis.org/A000108/list </para>
26        /// <para>Источник: https://oeis.org/A000108/list </para>
27        /// </remarks>
28        private static readonly double[] _catalans =
29        {
30            1D, 1D, 2D, 5D, 14D, 42D, 132D, 429D, 1430D, 4862D, 16796D, 58786D,
31            ↪ 208012D,
32            742900D, 2674440D, 9694845D, 35357670D, 129644790D, 477638700D, 1767263190D,
33            6564120420D, 24466267020D, 91482563640D, 343059613650D, 1289904147324D,
34            ↪ 4861946401452D,
35            18367353072152D, 69533550916004D, 263747951750360D, 1002242216651368D,
36            ↪ 3814986502092304D
37        };
38
39        public static double Factorial(double n)
40        {
41            if (n <= 1)
42            {
43                return 1;
44            }
45            if (n < _factorials.Length)
46            {
47

```

```

44         return _factorials[(int)n];
45     }
46     return n * Factorial(n - 1);
47 }
48
49 public static double Catalan(double n)
50 {
51     if (n <= 1)
52     {
53         return 1;
54     }
55     if (n < _catalans.Length)
56     {
57         return _catalans[(int)n];
58     }
59     return Factorial(2 * n) / (Factorial(n + 1) * Factorial(n));
60 }
61
62 [MethodImpl(MethodImplOptions.AggressiveInlining)]
63 public static bool IsPowerOfTwo(ulong x) => (x & x - 1) == 0;
64
65 [MethodImpl(MethodImplOptions.AggressiveInlining)]
66 public static T Abs<T>(T x) => Math<T>.Abs(x);
67
68 [MethodImpl(MethodImplOptions.AggressiveInlining)]
69 public static T Negate<T>(T x) => Math<T>.Negate(x);
70 }
71 }

```

#### 1.10 ./Platform.Numbers/MathExtensions.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.Numbers
6  {
7      public static class MathExtensions
8      {
9          [MethodImpl(MethodImplOptions.AggressiveInlining)]
10         public static T Abs<T>(this ref T x) where T : struct => x = Math<T>.Abs(x);
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public static T Negate<T>(this ref T x) where T : struct => x = Math<T>.Negate(x);
14     }
15 }

```

#### 1.11 ./Platform.Numbers/Math[T].cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Exceptions;
4  using Platform.Reflection;
5
6  // ReSharper disable StaticFieldInGenericType
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Numbers
10 {
11     public static class Math<T>
12     {
13         public static readonly Func<T, T> Abs = CompileAbsDelegate();
14         public static readonly Func<T, T> Negate = CompileNegateDelegate();
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         private static Func<T, T> CompileAbsDelegate()
18         {
19             return DelegateHelpers.Compile<Func<T, T>>(emitter =>
20             {
21                 Ensure.Always.IsNumeric<T>();
22                 emitter.LoadArgument(0);
23                 if (NumericType<T>.IsSigned)
24                 {
25                     emitter.Call(typeof(System.Math).GetMethod("Abs", Types<T>.Array));
26                 }
27                 emitter.Return();
28             });
29         }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         private static Func<T, T> CompileNegateDelegate()

```

```

33     {
34         return DelegateHelpers.Compile<Func<T, T>>(emitter =>
35         {
36             emitter.LoadArgument(0);
37             emitter.Negate();
38             emitter.Return();
39         });
40     }
41 }
42 }

```

### 1.12 ./Platform.Numbers.Tests/ArithmeticExtensionsTests.cs

```

1  using Xunit;
2
3  namespace Platform.Numbers.Tests
4  {
5      public static class ArithmeticExtensionsTests
6      {
7          [Fact]
8          public static void IncrementTest()
9          {
10             var number = 0UL;
11             var returnValue = number.Increment();
12             Assert.Equal(1UL, returnValue);
13             Assert.Equal(1UL, number);
14         }
15
16         [Fact]
17         public static void DecrementTest()
18         {
19             var number = 1UL;
20             var returnValue = number.Decrement();
21             Assert.Equal(0UL, returnValue);
22             Assert.Equal(0UL, number);
23         }
24     }
25 }

```

### 1.13 ./Platform.Numbers.Tests/ArithmeticTests.cs

```

1  using System;
2  using Xunit;
3
4  namespace Platform.Numbers.Tests
5  {
6      public static class ArithmeticTests
7      {
8          [Fact]
9          public static void CompiledOperationsTest()
10         {
11             Assert.True(Arithmetic<short>.Add(1, 2) == 3);
12             Assert.True(Arithmetic<short>.Subtract(2, 1) == 1);
13             Assert.True(Arithmetic<byte>.Increment(1) == 2);
14             Assert.True(Arithmetic<ulong>.Decrement(2) == 1);
15             Assert.Throws<NotSupportedException>(() => Arithmetic<string>.Subtract("1", "2"));
16         }
17     }
18 }

```

### 1.14 ./Platform.Numbers.Tests/BitTests.cs

```

1  using System;
2  using Xunit;
3
4  namespace Platform.Numbers.Tests
5  {
6      public static class BitTests
7      {
8          [Theory]
9          [InlineData(00, -1)] // 0000 0000 (none, -1)
10         [InlineData(01, 00)] // 0000 0001 (first, 0)
11         [InlineData(08, 03)] // 0000 1000 (forth, 3)
12         [InlineData(88, 03)] // 0101 1000 (forth, 3)
13         public static void GetLowestBitPositionTest(ulong value, int expectedPosition)
14         {
15             Assert.True(Bit.GetLowestPosition(value) == expectedPosition);
16         }
17
18         [Fact]
19         public static void ByteBitwiseOperationsTest()

```

```

20 {
21     Assert.True(Bit<byte>.Not(2) == unchecked((byte)~2));
22     Assert.True(Bit<byte>.Or(1, 2) == (1 | 2));
23     Assert.True(Bit<byte>.And(1, 2) == (1 & 2));
24     Assert.True(Bit<byte>.ShiftLeft(1, 2) == (1 << 2));
25     Assert.True(Bit<byte>.ShiftRight(1, 2) == (1 >> 2));
26 }
27
28 [Fact]
29 public static void UInt16BitwiseOperationsTest()
30 {
31     Assert.True(Bit<ushort>.Not(2) == unchecked((ushort)~2));
32     Assert.True(Bit<ushort>.Or(1, 2) == (1 | 2));
33     Assert.True(Bit<ushort>.And(1, 2) == (1 & 2));
34     Assert.True(Bit<ushort>.ShiftLeft(1, 2) == (1 << 2));
35     Assert.True(Bit<ushort>.ShiftRight(1, 2) == (1 >> 2));
36 }
37
38 [Fact]
39 public static void UInt32BitwiseOperationsTest()
40 {
41     Assert.True(Bit<uint>.Not(2) == unchecked((uint)~2));
42     Assert.True(Bit<uint>.Or(1, 2) == (1 | 2));
43     Assert.True(Bit<uint>.And(1, 2) == (1 & 2));
44     Assert.True(Bit<uint>.ShiftLeft(1, 2) == (1 << 2));
45     Assert.True(Bit<uint>.ShiftRight(1, 2) == (1 >> 2));
46 }
47
48 [Fact]
49 public static void UInt64BitwiseOperationsTest()
50 {
51     Assert.True(Bit<ulong>.Not(2) == unchecked((ulong)~2));
52     Assert.True(Bit<ulong>.Or(1, 2) == (1 | 2));
53     Assert.True(Bit<ulong>.And(1, 2) == (1 & 2));
54     Assert.True(Bit<ulong>.ShiftLeft(1, 2) == (1 << 2));
55     Assert.True(Bit<ulong>.ShiftRight(1, 2) == (1 >> 2));
56 }
57
58 [Fact]
59 public static void PartialReadWriteTest()
60 {
61     {
62         uint firstValue = 1;
63         uint secondValue = 1543;
64
65         // Pack (join) two values at the same time
66         uint value = secondValue << 1 | firstValue;
67
68         uint unpackagedFirstValue = value & 1;
69         uint unpackagedSecondValue = (value & 0xFFFFFFF0) >> 1;
70
71         Assert.True(firstValue == unpackagedFirstValue);
72         Assert.True(secondValue == unpackagedSecondValue);
73
74         // Using universal functions:
75         Assert.True(PartialRead(value, 0, 1) == firstValue);
76         Assert.True(PartialRead(value, 1, -1) == secondValue);
77
78         firstValue = 0;
79         secondValue = 6892;
80
81         value = PartialWrite(value, firstValue, 0, 1);
82         value = PartialWrite(value, secondValue, 1, -1);
83
84         Assert.True(PartialRead(value, 0, 1) == firstValue);
85         Assert.True(PartialRead(value, 1, -1) == secondValue);
86     }
87
88     {
89         uint firstValue = 1;
90         uint secondValue = 1543;
91
92         // Pack (join) two values at the same time
93         uint value = secondValue << 1 | firstValue;
94
95         uint unpackagedFirstValue = value & 1;
96         uint unpackagedSecondValue = (value & 0xFFFFFFF0) >> 1;
97
98         Assert.True(firstValue == unpackagedFirstValue);
99         Assert.True(secondValue == unpackagedSecondValue);

```

```

100
101 // Using universal functions:
102 Assert.True(Bit.PartialRead(value, 0, 1) == firstValue);
103 Assert.True(Bit.PartialRead(value, 1, -1) == secondValue);
104
105 firstValue = 0;
106 secondValue = 6892;
107
108 value = Bit.PartialWrite(value, firstValue, 0, 1);
109 value = Bit.PartialWrite(value, secondValue, 1, -1);
110
111 Assert.True(Bit.PartialRead(value, 0, 1) == firstValue);
112 Assert.True(Bit.PartialRead(value, 1, -1) == secondValue);
113 }
114
115 {
116     uint firstValue = 1;
117     uint secondValue = 1543;
118
119     // Pack (join) two values at the same time
120     uint value = secondValue << 1 | firstValue;
121
122     uint unpackagedFirstValue = value & 1;
123     uint unpackagedSecondValue = (value & 0xFFFFFFF) >> 1;
124
125     Assert.True(firstValue == unpackagedFirstValue);
126     Assert.True(secondValue == unpackagedSecondValue);
127
128     // Using universal functions:
129     var readMasksAndShiftFor0And1 = GetReadMaskAndShift(0, 1);
130     var readMasksAndShiftFor1AndMinus1 = GetReadMaskAndShift(1, -1);
131     var writeMasksAndShiftFor0And1 = GetWriteMasksAndShift(0, 1);
132     var writeMasksAndShiftFor1AndMinus1 = GetWriteMasksAndShift(1, -1);
133
134     Assert.True(PartialRead(value, readMasksAndShiftFor0And1) == firstValue);
135     Assert.True(PartialRead(value, readMasksAndShiftFor1AndMinus1) == secondValue);
136
137     firstValue = 0;
138     secondValue = 6892;
139
140     value = PartialWrite(value, firstValue, writeMasksAndShiftFor0And1);
141     value = PartialWrite(value, secondValue, writeMasksAndShiftFor1AndMinus1);
142
143     Assert.True(PartialRead(value, readMasksAndShiftFor0And1) == firstValue);
144     Assert.True(PartialRead(value, readMasksAndShiftFor1AndMinus1) == secondValue);
145 }
146 }
147
148 // TODO: Can be optimized using precalculation of TargetMask and SourceMask
149 private static uint PartialWrite(uint target, uint source, int shift, int limit)
150 {
151     if (shift < 0)
152     {
153         shift = 32 + shift;
154     }
155     if (limit < 0)
156     {
157         limit = 32 + limit;
158     }
159     var sourceMask = ~(uint.MaxValue << limit) & uint.MaxValue;
160     var targetMask = ~(sourceMask << shift);
161     return target & targetMask | (source & sourceMask) << shift;
162 }
163
164 private static uint PartialRead(uint target, int shift, int limit)
165 {
166     if (shift < 0)
167     {
168         shift = 32 + shift;
169     }
170     if (limit < 0)
171     {
172         limit = 32 + limit;
173     }
174     var sourceMask = ~(uint.MaxValue << limit) & uint.MaxValue;
175     var targetMask = sourceMask << shift;
176     return (target & targetMask) >> shift;
177 }
178
179 private static Tuple<uint, uint, int> GetWriteMasksAndShift(int shift, int limit)

```

```

180     {
181         if (shift < 0)
182         {
183             shift = 32 + shift;
184         }
185         if (limit < 0)
186         {
187             limit = 32 + limit;
188         }
189         var sourceMask = ~(uint.MaxValue << limit) & uint.MaxValue;
190         var targetMask = ~(sourceMask << shift);
191         return new Tuple<uint, uint, int>(targetMask, sourceMask, shift);
192     }
193
194     private static Tuple<uint, int> GetReadMaskAndShift(int shift, int limit)
195     {
196         if (shift < 0)
197         {
198             shift = 32 + shift;
199         }
200         if (limit < 0)
201         {
202             limit = 32 + limit;
203         }
204         var sourceMask = ~(uint.MaxValue << limit) & uint.MaxValue;
205         var targetMask = sourceMask << shift;
206         return new Tuple<uint, int>(targetMask, shift);
207     }
208
209     private static uint PartialWrite(uint target, uint targetMask, uint source, uint
    ↪ sourceMask, int shift) => target & targetMask | (source & sourceMask) << shift;
210
211     private static uint PartialWrite(uint target, uint source, Tuple<uint, uint, int>
    ↪ masksAndShift) => PartialWrite(target, masksAndShift.Item1, source,
    ↪ masksAndShift.Item2, masksAndShift.Item3);
212
213     private static uint PartialRead(uint target, uint targetMask, int shift) => (target &
    ↪ targetMask) >> shift;
214
215     private static uint PartialRead(uint target, Tuple<uint, int> masksAndShift) =>
    ↪ PartialRead(target, masksAndShift.Item1, masksAndShift.Item2);
216
217     [Fact]
218     public static void BugWithLoadingConstantOf8Test()
219     {
220         Bit<byte>.PartialWrite(0, 1, 5, -5);
221     }
222 }
223 }

```

### 1.15 ./Platform.Numbers.Tests/IntegerTests.cs

```

1  using System;
2  using Xunit;
3
4  namespace Platform.Numbers.Tests
5  {
6      public static class IntegerTests
7      {
8          [Fact]
9          [Obsolete]
10         public static void SignedIntegersTest()
11         {
12             var integer = -10;
13             Assert.True(((Integer)integer) == -10L);
14         }
15     }
16 }

```

### 1.16 ./Platform.Numbers.Tests/MathExtensionsTests.cs

```

1  using Xunit;
2
3  namespace Platform.Numbers.Tests
4  {
5      public static class MathExtensionsTests
6      {
7          [Fact]
8          public static void AbsTest()
9          {
10             var number = -1L;

```

```

11         var returnValue = number.Abs();
12         Assert.Equal(1L, returnValue);
13         Assert.Equal(1L, number);
14     }
15
16     [Fact]
17     public static void NegateTest()
18     {
19         var number = 2L;
20         var returnValue = number.Negate();
21         Assert.Equal(-2L, returnValue);
22         Assert.Equal(-2L, number);
23     }
24
25     [Fact]
26     public static void UnsignedNegateTest()
27     {
28         var number = 2UL;
29         var returnValue = number.Negate();
30         Assert.Equal(18446744073709551614, returnValue);
31         Assert.Equal(18446744073709551614, number);
32     }
33 }
34 }

```

### 1.17 ./Platform.Numbers.Tests/MathTests.cs

```

1  using Xunit;
2
3  namespace Platform.Numbers.Tests
4  {
5      public static class MathTests
6      {
7          [Fact]
8          public static void CompiledOperationsTest()
9          {
10             Assert.True(Math.Abs(Arithmetic<double>.Subtract(3D, 2D) - 1D) < 0.01);
11         }
12     }
13 }

```

### 1.18 ./Platform.Numbers.Tests/SystemTests.cs

```

1  using Xunit;
2
3  namespace Platform.Numbers.Tests
4  {
5      public static class SystemTests
6      {
7          [Fact]
8          public static void PossiblePackTwoValuesIntoOneTest()
9          {
10             uint value = 0;
11
12             // Set one to first bit
13             value |= 1;
14
15             Assert.True(value == 1);
16
17             // Set zero to first bit
18             value &= 0xFFFFFFFF;
19
20             // Get first bit
21             uint read = value & 1;
22
23             Assert.True(read == 0);
24
25             uint firstValue = 1;
26             uint secondValue = 1543;
27
28             // Pack (join) two values at the same time
29             value = (secondValue << 1) | firstValue;
30
31             uint unpackedFirstValue = value & 1;
32             uint unpackedSecondValue = (value & 0xFFFFFFFF) >> 1;
33
34             Assert.True(firstValue == unpackedFirstValue);
35             Assert.True(secondValue == unpackedSecondValue);
36
37             // Using universal functions:
38
39             Assert.True(PartialRead(value, 0, 1) == firstValue);

```

```

40     Assert.True(PartialRead(value, 1, -1) == secondValue);
41
42     firstValue = 0;
43     secondValue = 6892;
44
45     value = PartialWrite(value, firstValue, 0, 1);
46     value = PartialWrite(value, secondValue, 1, -1);
47
48     Assert.True(PartialRead(value, 0, 1) == firstValue);
49     Assert.True(PartialRead(value, 1, -1) == secondValue);
50 }
51
52 private static uint PartialWrite(uint target, uint source, int shift, int limit)
53 {
54     if (shift < 0)
55     {
56         shift = 32 + shift;
57     }
58     if (limit < 0)
59     {
60         limit = 32 + limit;
61     }
62     var sourceMask = ~(uint.MaxValue << limit) & uint.MaxValue;
63     var targetMask = ~(sourceMask << shift);
64     return (target & targetMask) | ((source & sourceMask) << shift);
65 }
66
67 private static uint PartialRead(uint target, int shift, int limit)
68 {
69     if (shift < 0)
70     {
71         shift = 32 + shift;
72     }
73     if (limit < 0)
74     {
75         limit = 32 + limit;
76     }
77     var sourceMask = ~(uint.MaxValue << limit) & uint.MaxValue;
78     var targetMask = sourceMask << shift;
79     return (target & targetMask) >> shift;
80 }
81 }
82 }

```



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