

## LinksPlatform's Platform.Numbers Class Library

### ./Platform.Numbers/Arithmetic.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 Arithmetic
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public static T Add<T>(T x, T y) => Arithmetic<T>.Add(x, y);
11
12        [MethodImpl(MethodImplOptions.AggressiveInlining)]
13        public static T Subtract<T>(T x, T y) => Arithmetic<T>.Subtract(x, y);
14
15        [MethodImpl(MethodImplOptions.AggressiveInlining)]
16        public static T Subtract<T>(Integer<T> x, Integer<T> y) => Arithmetic<T>.Subtract(x, y);
17
18        [MethodImpl(MethodImplOptions.AggressiveInlining)]
19        public static T Increment<T>(T x) => Arithmetic<T>.Increment(x);
20
21        [MethodImpl(MethodImplOptions.AggressiveInlining)]
22        public static T Decrement<T>(T x) => Arithmetic<T>.Decrement(x);
23    }
24 }
```

### ./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 }
```

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

```
1 using System;
2 using Platform.Exceptions;
3 using Platform.Reflection;
4
5 // ReSharper disable StaticFieldInGenericType
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Numbers
9 {
10    public static class Arithmetic<T>
11    {
12        public static readonly Func<T, T, T> Add;
13        public static readonly Func<T, T, T> Subtract;
14        public static readonly Func<T, T> Increment;
15        public static readonly Func<T, T> Decrement;
16
17        static Arithmetic()
18        {
19            Add = CompileAddDelegate();
20            Subtract = CompileSubtractDelegate();
21            Increment = CompileIncrementDelegate();
22            Decrement = CompileDecrementDelegate();
23        }
24
25        private static Func<T, T, T> CompileAddDelegate()
26        {
27            return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
28            {
29                Ensure.Always.IsNumeric<T>();
30                emitter.LoadArguments(0, 1);
31                emitter.Add();
32                emitter.Return();
33            });
34        }
35    }
36 }
```

```

33     });
34 }
35
36 private static Func<T, T, T> CompileSubtractDelegate()
37 {
38     return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
39     {
40         Ensure.Always.IsNumeric<T>();
41         emitter.LoadArguments(0, 1);
42         emitter.Subtract();
43         emitter.Return();
44     });
45 }
46
47 private static Func<T, T> CompileIncrementDelegate()
48 {
49     return DelegateHelpers.Compile<Func<T, T>>(emitter =>
50     {
51         Ensure.Always.IsNumeric<T>();
52         emitter.LoadArgument(0);
53         emitter.Increment<T>();
54         emitter.Return();
55     });
56 }
57
58 private static Func<T, T> CompileDecrementDelegate()
59 {
60     return DelegateHelpers.Compile<Func<T, T>>(emitter =>
61     {
62         Ensure.Always.IsNumeric<T>();
63         emitter.LoadArgument(0);
64         emitter.Decrement<T>();
65         emitter.Return();
66     });
67 }
68 }
69 }

```

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

```

```

41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     public static T And<T>(T x, T y) => Bit<T>.And(x, y);
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     public static T ShiftLeft<T>(T x, int y) => Bit<T>.ShiftLeft(x, y);
46
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     public static T ShiftRight<T>(T x, int y) => Bit<T>.ShiftRight(x, y);
49
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     public static T PartialWrite<T>(T target, T source, int shift, int limit) =>
52         ↪ Bit<T>.PartialWrite(target, source, shift, limit);
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     public static T PartialRead<T>(T target, int shift, int limit) =>
56         ↪ Bit<T>.PartialRead(target, shift, limit);
57 }
58
59 ./Platform.Numbers/BitExtensions.cs
60 1 using System.Runtime.CompilerServices;
61 2
62 3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
63 4
64 5 namespace Platform.Numbers
65 6 {
66 7     public static class BitwiseExtensions
67 8     {
68 9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
69 10        public static T Not<T>(this ref T target) where T : struct => target = Bit.Not(target);
70 11
71 12        [MethodImpl(MethodImplOptions.AggressiveInlining)]
72 13        public static T PartialWrite<T>(this ref T target, T source, int shift, int limit) where
73 14        ↪ T : struct => target = Bit<T>.PartialWrite(target, source, shift, limit);
74 15
75 16        [MethodImpl(MethodImplOptions.AggressiveInlining)]
76 17        public static T PartialRead<T>(this T target, int shift, int limit) =>
77 18        ↪ Bit<T>.PartialRead(target, shift, limit);
79 }
80
81 ./Platform.Numbers/Bit[T].cs
82 1 using System;
83 2 using System.Reflection.Emit;
84 3 using Platform.Exceptions;
85 4 using Platform.Reflection;
86 5
87 6 // ReSharper disable StaticFieldInGenericType
88 7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
89 8
90 9 namespace Platform.Numbers
91 10 {
92 11     public static class Bit<T>
93 12     {
94 13         public static readonly Func<T, T> Not;
95 14         public static readonly Func<T, T, T> Or;
96 15         public static readonly Func<T, T, T> And;
97 16         public static readonly Func<T, int, T> ShiftLeft;
98 17         public static readonly Func<T, int, T> ShiftRight;
99 18         public static readonly Func<T, T, int, int, T> PartialWrite;
100 19         public static readonly Func<T, int, int, T> PartialRead;
101 20
102 21         static Bit()
103 22         {
104 23             Not = CompileNotDelegate();
105 24             Or = CompileOrDelegate();
106 25             And = CompileAndDelegate();
107 26             ShiftLeft = CompileShiftLeftDelegate();
108 27             ShiftRight = CompileShiftRightDelegate();
109 28             PartialWrite = CompilePartialWriteDelegate();
110 29             PartialRead = CompilePartialReadDelegate();
111 30         }
112 31
113 32         private static Func<T, T> CompileNotDelegate()
114 33         {
115 34             return DelegateHelpers.Compile<Func<T, T>>(emitter =>
116 35             {
117 36                 Ensure.Always.IsNumeric<T>();
118 37                 emitter.LoadArguments(0);

```

```

38         emitter.Not();
39         emitter.Return();
40     });
41 }
42
43 private static Func<T, T, T> CompileOrDelegate()
44 {
45     return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
46     {
47         Ensure.Always.IsNumeric<T>();
48         emitter.LoadArguments(0, 1);
49         emitter.Or();
50         emitter.Return();
51     });
52 }
53
54 private static Func<T, T, T> CompileAndDelegate()
55 {
56     return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
57     {
58         Ensure.Always.IsNumeric<T>();
59         emitter.LoadArguments(0, 1);
60         emitter.And();
61         emitter.Return();
62     });
63 }
64
65 private static Func<T, int, T> CompileShiftLeftDelegate()
66 {
67     return DelegateHelpers.Compile<Func<T, int, T>>(emitter =>
68     {
69         Ensure.Always.IsNumeric<T>();
70         emitter.LoadArguments(0, 1);
71         emitter.ShiftLeft();
72         emitter.Return();
73     });
74 }
75
76 private static Func<T, int, T> CompileShiftRightDelegate()
77 {
78     return DelegateHelpers.Compile<Func<T, int, T>>(emitter =>
79     {
80         Ensure.Always.IsNumeric<T>();
81         emitter.LoadArguments(0, 1);
82         emitter.ShiftRight();
83         emitter.Return();
84     });
85 }
86
87 private static Func<T, T, int, int, T> CompilePartialWriteDelegate()
88 {
89     return DelegateHelpers.Compile<Func<T, T, int, int, T>>(emitter =>
90     {
91         Ensure.Always.IsNumeric<T>();
92         var constants = GetConstants();
93         var bitsNumber = constants.Item1;
94         var numberFilledWithOnes = constants.Item2;
95         ushort shiftArgument = 2;
96         ushort limitArgument = 3;
97         var checkLimit = emitter.DefineLabel();
98         var calculateSourceMask = emitter.DefineLabel();
99         // Check shift
100        emitter.LoadArgument(shiftArgument);
101        emitter.LoadConstant(0);
102        emitter.BranchIfGreaterOrEqual(checkLimit); // Skip fix
103        // Fix shift
104        emitter.LoadConstant(bitsNumber);
105        emitter.LoadArgument(shiftArgument);
106        emitter.Add();
107        emitter.StoreArgument(shiftArgument);
108        emitter.MarkLabel(checkLimit);
109        // Check limit
110        emitter.LoadArgument(limitArgument);
111        emitter.LoadConstant(0);
112        emitter.BranchIfGreaterOrEqual(calculateSourceMask); // Skip fix
113        // Fix limit
114        emitter.LoadConstant(bitsNumber);
115        emitter.LoadArgument(limitArgument);

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```

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

```

```

194         emitter.LoadArgument(shiftArgument);
195         emitter.ShiftRight();
196         emitter.Return();
197     });
198 }
199
200 private static Tuple<int, T> GetConstants()
201 {
202     var type = typeof(T);
203     if (type == typeof(ulong))
204     {
205         return new Tuple<int, T>(64, (T)(object)ulong.MaxValue);
206     }
207     if (type == typeof(uint))
208     {
209         return new Tuple<int, T>(32, (T)(object)uint.MaxValue);
210     }
211     if (type == typeof(ushort))
212     {
213         return new Tuple<int, T>(16, (T)(object)ushort.MaxValue);
214     }
215     if (type == typeof(byte))
216     {
217         return new Tuple<int, T>(8, (T)(object)byte.MaxValue);
218     }
219     throw new NotSupportedException();
220 }
221 }
222 }

```

# ./Platform.Numbers/Integer.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.Numbers
8  {
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) => To.UInt64(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) => To.UInt64(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) => To.UInt64(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) => To.UInt64(integer);
39
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         public static implicit operator Integer(bool integer) => To.UInt64(integer);
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) => To.Int64(integer.Value);
48
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

50     public static implicit operator uint(Integer integer) => To.UInt32(integer.Value);
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     public static implicit operator int(Integer integer) => To.Int32(integer.Value);
54
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     public static implicit operator ushort(Integer integer) => To.UInt16(integer.Value);
57
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     public static implicit operator short(Integer integer) => To.Int16(integer.Value);
60
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     public static implicit operator byte(Integer integer) => To.Byte(integer.Value);
63
64     [MethodImpl(MethodImplOptions.AggressiveInlining)]
65     public static implicit operator sbyte(Integer integer) => To.SByte(integer.Value);
66
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     public static implicit operator bool(Integer integer) => To.Boolean(integer.Value);
69
70     [MethodImpl(MethodImplOptions.AggressiveInlining)]
71     public bool Equals(Integer other) => Value == other.Value;
72
73     [MethodImpl(MethodImplOptions.AggressiveInlining)]
74     public override string ToString() => Value.ToString();
75 }
76 }

```

./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  using Platform.Converters;
7
8  // ReSharper disable StaticFieldInGenericType
9  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
10 #pragma warning disable RECS0108 // Warns about static fields in generic types
11
12 namespace Platform.Numbers
13 {
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         static Integer()
27         {
28             _create = CompileCreateDelegate();
29             try
30             {
31                 Zero = default;
32                 One = Arithmetic.Increment(Zero);
33                 Two = Arithmetic.Increment(One);
34             }
35             catch (Exception exception)
36             {
37                 exception.Ignore();
38             }
39
40             [MethodImpl(MethodImplOptions.AggressiveInlining)]
41             public Integer(T value) => Value = value;
42
43             [MethodImpl(MethodImplOptions.AggressiveInlining)]
44             public static implicit operator Integer(Integer<T> integer)
45             {
46                 if (typeof(T) == typeof(Integer))
47                 {
48                     return (Integer)(object)integer.Value;
49                 }
50                 return Convert.ToUInt64(integer.Value);

```

```

51     }
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     public static implicit operator ulong(Integer<T> integer) => ((Integer)integer).Value;
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     public static implicit operator T(Integer<T> integer) => integer.Value;
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     public static implicit operator Integer<T>(T integer) => new Integer<T>(integer);
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     public static implicit operator Integer<T>(ulong integer) => _create(integer);
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     public static implicit operator Integer<T>(Integer integer) => _create(integer.Value);
67
68     [MethodImpl(MethodImplOptions.AggressiveInlining)]
69     public static implicit operator Integer<T>(long integer) => To.UInt64(integer);
70
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     public static implicit operator Integer<T>(uint integer) => new Integer(integer);
73
74     [MethodImpl(MethodImplOptions.AggressiveInlining)]
75     public static implicit operator Integer<T>(int integer) => To.UInt64(integer);
76
77     [MethodImpl(MethodImplOptions.AggressiveInlining)]
78     public static implicit operator Integer<T>(ushort integer) => new Integer(integer);
79
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     public static implicit operator Integer<T>(short integer) => To.UInt64(integer);
82
83     [MethodImpl(MethodImplOptions.AggressiveInlining)]
84     public static implicit operator Integer<T>(byte integer) => new Integer(integer);
85
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     public static implicit operator Integer<T>(sbyte integer) => To.UInt64(integer);
88
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     public static implicit operator Integer<T>(bool integer) => To.UInt64(integer);
91
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     public static implicit operator long(Integer<T> integer) => To.Int64(integer);
94
95     [MethodImpl(MethodImplOptions.AggressiveInlining)]
96     public static implicit operator uint(Integer<T> integer) => To.UInt32(integer);
97
98     [MethodImpl(MethodImplOptions.AggressiveInlining)]
99     public static implicit operator int(Integer<T> integer) => To.Int32(integer);
100
101     [MethodImpl(MethodImplOptions.AggressiveInlining)]
102     public static implicit operator ushort(Integer<T> integer) => To.UInt16(integer);
103
104     [MethodImpl(MethodImplOptions.AggressiveInlining)]
105     public static implicit operator short(Integer<T> integer) => To.Int16(integer);
106
107     [MethodImpl(MethodImplOptions.AggressiveInlining)]
108     public static implicit operator byte(Integer<T> integer) => To.Byte(integer);
109
110     [MethodImpl(MethodImplOptions.AggressiveInlining)]
111     public static implicit operator sbyte(Integer<T> integer) => To.SByte(integer);
112
113     [MethodImpl(MethodImplOptions.AggressiveInlining)]
114     public static implicit operator bool(Integer<T> integer) => To.Boolean(integer);
115
116     [MethodImpl(MethodImplOptions.AggressiveInlining)]
117     public bool Equals(Integer<T> other) => _equalityComparer.Equals(Value, other.Value);
118
119     [MethodImpl(MethodImplOptions.AggressiveInlining)]
120     public override string ToString() => Value.ToString();
121
122     private static Func<ulong, Integer<T>> CompileCreateDelegate()
123     {
124         return DelegateHelpers.Compile<Func<ulong, Integer<T>>>(emitter =>
125         {
126             if (typeof(T) != typeof(Integer))
127             {
128                 Ensure.Always.CanBeNumeric<T>();
129             }
130             emitter.LoadArgument(0);

```



```

131         if (typeof(T) != typeof(ulong) && typeof(T) != typeof(Integer))
132         {
133             emitter.Call(typeof(To).GetMethod(typeof(T).Name, Types<ulong>.Array));
134         }
135         if (NumericType<T>.IsNullable)
136         {
137             emitter.NewObject(typeof(T), NumericType<T>.UnderlyingType);
138         }
139         if (typeof(T) == typeof(Integer))
140         {
141             emitter.NewObject(typeof(Integer), typeof(ulong));
142         }
143         emitter.NewObject(typeof(Integer<T>), typeof(T));
144         emitter.Return();
145     });
146 }
147 }
148 }

```

## ./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         /// Source: https://oeis.org/A000142/list
14         /// </remarks>
15         private static readonly ulong[] _factorials =
16         {
17             1, 1, 2, 6, 24, 120, 720, 5040, 40320, 362880, 3628800, 39916800,
18             479001600, 6227020800, 87178291200, 1307674368000, 20922789888000,
19             355687428096000, 6402373705728000, 121645100408832000, 2432902008176640000
20         };
21
22         /// <remarks>
23         /// Source: https://oeis.org/A000108/list
24         /// </remarks>
25         private static readonly ulong[] _catalans =
26         {
27             1, 1, 2, 5, 14, 42, 132, 429, 1430, 4862, 16796, 58786, 208012,
28             742900, 2674440, 9694845, 35357670, 129644790, 477638700, 1767263190,
29             6564120420, 24466267020, 91482563640, 343059613650, 1289904147324, 4861946401452,
30             18367353072152, 69533550916004, 263747951750360, 1002242216651368, 3814986502092304
31         };
32
33         public static double Factorial(double n)
34         {
35             if (n <= 1)
36             {
37                 return 1;
38             }
39             if (n < _factorials.Length)
40             {
41                 return _factorials[(int)n];
42             }
43             return n * Factorial(n - 1);
44         }
45
46         public static double Catalan(double n)
47         {
48             if (n <= 1)
49             {
50                 return 1;
51             }
52             if (n < _catalans.Length)
53             {
54                 return _catalans[(int)n];
55             }
56             return Factorial(2 * n) / (Factorial(n + 1) * Factorial(n));
57         }
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

60     public static bool IsPowerOfTwo(ulong x) => (x & x - 1) == 0;
61
62     [MethodImpl(MethodImplOptions.AggressiveInlining)]
63     public static T Abs<T>(T x) => Math<T>.Abs(x);
64
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     public static T Negate<T>(T x) => Math<T>.Negate(x);
67 }
68 }

```

#### ./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 }

```

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

```

1  using System;
2  using System.Reflection;
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;
14         public static readonly Func<T, T> Negate;
15
16         static Math()
17         {
18             Abs = CompileAbsDelegate();
19             Negate = CompileNegateDelegate();
20         }
21
22         private static Func<T, T> CompileAbsDelegate()
23         {
24             return DelegateHelpers.Compile<Func<T, T>>(emitter =>
25             {
26                 Ensure.Always.IsNumeric<T>();
27                 emitter.LoadArgument(0);
28                 if (NumericType<T>.IsSigned)
29                 {
30                     emitter.Call(typeof(System.Math).GetMethod("Abs", Types<T>.Array));
31                 }
32                 emitter.Return();
33             });
34         }
35
36         private static Func<T, T> CompileNegateDelegate()
37         {
38             return DelegateHelpers.Compile<Func<T, T>>(emitter =>
39             {
40                 emitter.LoadArgument(0);
41                 emitter.Negate();
42                 emitter.Return();
43             });
44         }
45     }
46 }

```

#### ./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 }

```

./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 }

```

./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 }

```

```

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 }

```

#### ./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 }

```

#### ./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 }

```

./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 unpackagedFirstValue = value & 1;
32             uint unpackagedSecondValue = (value & 0xFFFFFFFF) >> 1;
33
34             Assert.True(firstValue == unpackagedFirstValue);
35             Assert.True(secondValue == unpackagedSecondValue);
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 }



## Index

- ./Platform.Numbers.Tests/ArithmeticExtensionsTests.cs, 10
- ./Platform.Numbers.Tests/ArithmeticTests.cs, 11
- ./Platform.Numbers.Tests/BitTests.cs, 11
- ./Platform.Numbers.Tests/MathExtensionsTests.cs, 14
- ./Platform.Numbers.Tests/MathTests.cs, 14
- ./Platform.Numbers.Tests/SystemTests.cs, 14
- ./Platform.Numbers/Arithmetic.cs, 1
- ./Platform.Numbers/ArithmeticExtensions.cs, 1
- ./Platform.Numbers/Arithmetic[T].cs, 1
- ./Platform.Numbers/Bit.cs, 2
- ./Platform.Numbers/BitExtensions.cs, 3
- ./Platform.Numbers/Bit[T].cs, 3
- ./Platform.Numbers/Integer.cs, 6
- ./Platform.Numbers/Integer[T].cs, 7
- ./Platform.Numbers/Math.cs, 9
- ./Platform.Numbers/MathExtensions.cs, 10
- ./Platform.Numbers/Math[T].cs, 10