

LinksPlatform's Platform.Numbers Class Library

1.1 ./csharp/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      /// <summary>
8      /// <para>Binary mathematical operations.</para>
9      /// <para>Бинарные математические операции.</para>
10     /// </summary>
11     public static class Arithmetic
12     {
13         /// <summary>
14         /// <para>Performing adding the x and y arguments.</para>
15         /// <para>Выполняет ложение аргументов x и y.</para>
16         /// </summary>
17         /// <param name="x">
18         /// <para>The first term.</para>
19         /// <para>Первое слагаемое.</para>
20         /// </param>
21         /// <param name="y">
22         /// <para>The second term.</para>
23         /// <para>Второе слагаемое.</para>
24         /// </param>
25         /// <returns>
26         /// <para>Sum of x and y.</para>
27         /// <para>Сумма x и y.</para>
28         /// </returns>
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public static T Add<T>(T x, T y) => Arithmetic<T>.Add(x, y);
31
32         /// <summary>
33         /// <para>Performs subtracting x from y.</para>
34         /// <para>Выполняет вычитание x из y.</para>
35         /// </summary>
36         /// <param name="x">
37         /// <para>Minuend.</para>
38         /// <para>Уменьшаемое.</para>
39         /// </param>
40         /// <param name="y">
41         /// <para>Subtrahend.</para>
42         /// <para>Вычитаемое.</para>
43         /// </param>
44         /// <returns>
45         /// <para>Difference of x and y.</para>
46         /// <para>Разность x и y.</para>
47         /// </returns>
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         public static T Subtract<T>(T x, T y) => Arithmetic<T>.Subtract(x, y);
50
51         /// <summary>
52         /// <para>Performs multiplication the x and y.</para>
53         /// <para>Выполняет умножение x и y.</para>
54         /// </summary>
55         /// <param name="x">
56         /// <para>First multiplier.</para>
57         /// <para>Первый множитель.</para>
58         /// </param>
59         /// <param name="y">
60         /// <para>Second multiplier.</para>
61         /// <para>Второй множитель.</para>
62         /// </param>
63         /// <returns>
64         /// <para>Product of x and y.</para>
65         /// <para>Произведение x и y.</para>
66         /// </returns>
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         public static T Multiply<T>(T x, T y) => Arithmetic<T>.Multiply(x, y);
69
70         /// <summary>
71         /// <para>Performs dividing x by y.</para>
72         /// <para>Выполняет деление x на y.</para>
73         /// </summary>
74         /// <param name="x">
75         /// <para>Dividend.</para>
76         /// <para>Делимое.</para>
```

```

77     /// </param>
78     /// <param name="y">
79     /// <para>Divider.</para>
80     /// <para>Делитель.</para>
81     /// </param>
82     /// <returns>
83     /// <para>Quoitent of x and y.</para>
84     /// <para>Частное x и y.</para>
85     /// </returns>
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     public static T Divide<T>(T x, T y) => Arithmetic<T>.Divide(x, y);
88
89     /// <summary>
90     /// <para>Increasing the number x by one.</para>
91     /// <para>Увеличение числа x на единицу.</para>
92     /// </summary>
93     /// <param name="x">
94     /// <para>The number to increase.</para>
95     /// <para>Число для увеличения.</para>
96     /// </param>
97     /// <returns>
98     /// <para>Increase by one number x.</para>
99     /// <para>Увеличенное на единицу число x.</para>
100    /// </returns>
101    [MethodImpl(MethodImplOptions.AggressiveInlining)]
102    public static T Increment<T>(T x) => Arithmetic<T>.Increment(x);
103
104    /// <summary>
105    /// <para>Increases the value of argument x by one.</para>
106    /// <para>Увеличение значения аргумента x на единицу.</para>
107    /// </summary>
108    /// <param name="x">
109    /// <para>The argument to increase.</para>
110    /// <para>Аргумент для увеличения.</para>
111    /// </param>
112    /// <returns>
113    /// <para>Increased argument x value.</para>
114    /// <para>Увеличенное значение аргумента x.</para>
115    /// </returns>
116    [MethodImpl(MethodImplOptions.AggressiveInlining)]
117    public static T Increment<T>(ref T x) => x = Arithmetic<T>.Increment(x);
118
119    /// <summary>
120    /// <para>Decrease number x by one.</para>
121    /// <para>Уменьшение числа x на единицу.</para>
122    /// </summary>
123    /// <param name="x">
124    /// <para>The number to reduce.</para>
125    /// <para>Число для уменьшения.</para>
126    /// </param>
127    /// <returns>
128    /// <para>Decreased by one number x.</para>
129    /// <para>Уменьшенное на единицу число x.</para>
130    /// </returns>
131    [MethodImpl(MethodImplOptions.AggressiveInlining)]
132    public static T Decrement<T>(T x) => Arithmetic<T>.Decrement(x);
133
134    /// <summary>
135    /// <para>Decreases the value of the argument x by one.</para>
136    /// <para>Уменьшение значения аргумента x на единицу.</para>
137    /// </summary>
138    /// <param name="x">
139    /// <para>The argument to reduce.</para>
140    /// <para>Аргумент для уменьшения.</para>
141    /// </param>
142    /// <returns>
143    /// <para>Decreased argument x value.</para>
144    /// <para>Уменьшенное значение аргумента x.</para>
145    /// </returns>
146    [MethodImpl(MethodImplOptions.AggressiveInlining)]
147    public static T Decrement<T>(ref T x) => x = Arithmetic<T>.Decrement(x);
148
149 }

```

1.2 ./csharp/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 =
            ↳ Arithmetic<T>.Decrement(x);
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public static T Increment<T>(this ref T x) where T : struct => x =
            ↳ Arithmetic<T>.Increment(x);
14     }
15 }

```

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

```

1 using System;
2 using System.Reflection.Emit;
3 using System.Runtime.CompilerServices;
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
10 namespace Platform.Numbers
11 {
12     public static class Arithmetic<T>
13     {
14         public static readonly Func<T, T, T> Add = CompileAddDelegate();
15         public static readonly Func<T, T, T> Subtract = CompileSubtractDelegate();
16         public static readonly Func<T, T, T> Multiply = CompileMultiplyDelegate();
17         public static readonly Func<T, T, T> Divide = CompileDivideDelegate();
18         public static readonly Func<T, T> Increment = CompileIncrementDelegate();
19         public static readonly Func<T, T> Decrement = CompileDecrementDelegate();
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         private static Func<T, T, T> CompileAddDelegate()
23         {
24             return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
25             {
26                 Ensure.Always.IsNumeric<T>();
27                 emitter.LoadArguments(0, 1);
28                 emitter.Add();
29                 emitter.Return();
30             });
31         }
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         private static Func<T, T, T> CompileSubtractDelegate()
35         {
36             return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
37             {
38                 Ensure.Always.IsNumeric<T>();
39                 emitter.LoadArguments(0, 1);
40                 emitter.Subtract();
41                 emitter.Return();
42             });
43         }
44
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         private static Func<T, T, T> CompileMultiplyDelegate()
47         {
48             return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
49             {
50                 Ensure.Always.IsNumeric<T>();
51                 emitter.LoadArguments(0, 1);
52                 emitter.Emit(OpCodes.Mul);
53                 emitter.Return();
54             });
55         }
56
57         [MethodImpl(MethodImplOptions.AggressiveInlining)]
58         private static Func<T, T, T> CompileDivideDelegate()
59         {
60             return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
61             {
62                 Ensure.Always.IsNumeric<T>();
63                 emitter.LoadArguments(0, 1);

```

```

64         if(NumericType<T>.IsSigned)
65         {
66             emitter.Emit(OpCodes.Div);
67         }
68         else
69         {
70             emitter.Emit(OpCodes.Div_Un);
71         }
72         emitter.Return();
73     });
74 }
75
76 [MethodImpl(MethodImplOptions.AggressiveInlining)]
77 private static Func<T, T> CompileIncrementDelegate()
78 {
79     return DelegateHelpers.Compile<Func<T, T>>(emitter =>
80     {
81         Ensure.Always.IsNumeric<T>();
82         emitter.LoadArgument(0);
83         emitter.Increment<T>();
84         emitter.Return();
85     });
86 }
87
88 [MethodImpl(MethodImplOptions.AggressiveInlining)]
89 private static Func<T, T> CompileDecrementDelegate()
90 {
91     return DelegateHelpers.Compile<Func<T, T>>(emitter =>
92     {
93         Ensure.Always.IsNumeric<T>();
94         emitter.LoadArgument(0);
95         emitter.Decrement<T>();
96         emitter.Return();
97     });
98 }
99 }
100 }

```

1.4 ./csharp/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
6
7  namespace Platform.Numbers
8  {
9      /// <summary>
10     /// <para>A set of operations on the set bits of a number.</para>
11     /// <para>Набор операций над установленными битами числа.</para>
12     /// </summary>
13
14     public static class Bit
15     {
16         /// <summary>
17         /// <para>Counts the number of bits set in a number.</para>
18         /// <para>Подсчитывает количество установленных бит в числе.</para>
19         /// </summary>
20         /// <param>
21         /// <para>Bitwise number.</para>
22         /// <para>Число в битовом представлении.</para>
23         /// </param>
24         /// <returns>
25         /// <para>Number of bits set in a number.</para>
26         /// <para>Количество установленных бит в числе.</para>
27         /// </returns>
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public static long Count(long x)
30         {
31             long n = 0;
32             while (x != 0)
33             {
34                 n++;
35                 x &= x - 1;
36             }
37             return n;
38         }
39         /// <summary>
40         /// <para>Searches for the first bit set in a number.</para>

```

```

41     /// <para>Ищет первый установленный бит в числе.</para>
42     /// </summary>
43     /// <param>
44     /// <para>Bitwise number.</para>
45     /// <para>Число в битовом представлении.</para>
46     /// </param>
47     /// <returns>
48     /// <para>First bit set.</para>
49     /// <para>Первый установленный бит.</para>
50     /// </returns>
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     public static int GetLowestPosition(ulong value)
53     {
54         if (value == 0)
55         {
56             return -1;
57         }
58         var position = 0;
59         while ((value & 1UL) == 0)
60         {
61             value >>= 1;
62             ++position;
63         }
64         return position;
65     }
66
67     /// <summary>
68     /// <para>.</para>
69     /// <para>.</para>
70     /// </summary>
71     /// <returns>
72     /// <para>.</para>
73     /// <para>.</para>
74     /// </returns>
75     [MethodImpl(MethodImplOptions.AggressiveInlining)]
76     public static T Not<T>(T x) => Bit<T>.Not(x);
77
78     /// <summary>
79     /// <para>.</para>
80     /// <para>.</para>
81     /// </summary>
82     /// <returns>
83     /// <para>.</para>
84     /// <para>.</para>
85     /// </returns>
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     public static T Or<T>(T x, T y) => Bit<T>.Or(x, y);
88
89     /// <summary>
90     /// <para>.</para>
91     /// <para>.</para>
92     /// </summary>
93     /// <returns>
94     /// <para>.</para>
95     /// <para>.</para>
96     /// </returns>
97     [MethodImpl(MethodImplOptions.AggressiveInlining)]
98     public static T And<T>(T x, T y) => Bit<T>.And(x, y);
99
100    /// <summary>
101    /// <para>.</para>
102    /// <para>.</para>
103    /// </summary>
104    /// <returns>
105    /// <para>.</para>
106    /// <para>.</para>
107    /// </returns>
108    [MethodImpl(MethodImplOptions.AggressiveInlining)]
109    public static T ShiftLeft<T>(T x, int y) => Bit<T>.ShiftLeft(x, y);
110
111    /// <summary>
112    /// <para>.</para>
113    /// <para>.</para>
114    /// </summary>
115    /// <returns>
116    /// <para>.</para>
117    /// <para>.</para>
118    /// </returns>

```

```

119     [MethodImpl(MethodImplOptions.AggressiveInlining)]
120     public static T ShiftRight<T>(T x, int y) => Bit<T>.ShiftRight(x, y);
121
122     /// <summary>
123     /// <para>.</para>
124     /// <para>.</para>
125     /// </summary>
126     /// <returns>
127     /// <para>.</para>
128     /// <para>.</para>
129     /// </returns>
130     [MethodImpl(MethodImplOptions.AggressiveInlining)]
131     public static T PartialWrite<T>(T target, T source, int shift, int limit) =>
132         ↪ Bit<T>.PartialWrite(target, source, shift, limit);
133
134     /// <summary>
135     /// <para>.</para>
136     /// <para>.</para>
137     /// </summary>
138     /// <returns>
139     /// <para>.</para>
140     /// <para>.</para>
141     /// </returns>
142     [MethodImpl(MethodImplOptions.AggressiveInlining)]
143     public static T PartialRead<T>(T target, int shift, int limit) =>
144         ↪ Bit<T>.PartialRead(target, shift, limit);

```

1.5 ./csharp/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     /// <summary>
8     /// <returns> bit operations </returns>
9     /// </summary>
10    /* bit operations */
11    public static class BitwiseExtensions
12    {
13
14
15        [MethodImpl(MethodImplOptions.AggressiveInlining)]
16        public static T Not<T>(this ref T target) where T : struct => target = Bit.Not(target);
17
18        [MethodImpl(MethodImplOptions.AggressiveInlining)]
19        public static T PartialWrite<T>(this ref T target, T source, int shift, int limit) where
20            ↪ T : struct => target = Bit<T>.PartialWrite(target, source, shift, limit);
21
22        [MethodImpl(MethodImplOptions.AggressiveInlining)]
23        public static T PartialRead<T>(this T target, int shift, int limit) =>
24            ↪ Bit<T>.PartialRead(target, shift, limit);
25    }
26 }

```

1.6 ./csharp/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 }

```

```

21 [MethodImpl(MethodImplOptions.AggressiveInlining)]
22 private static Func<T, T> CompileNotDelegate()
23 {
24     return DelegateHelpers.Compile<Func<T, T>>(emitter =>
25     {
26         Ensure.Always.IsNumeric<T>();
27         emitter.LoadArguments(0);
28         emitter.Not();
29         emitter.Return();
30     });
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 ./csharp/Platform.Numbers/Math.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     /// <remarks>
9     /// Resizable array (FileMappedMemory) for values cache may be used. or cached oeis.org
10    /// </remarks>
11    public static class Math
12    {
13        /// <remarks>
14        /// <para>Source: https://oeis.org/A000142/list </para>
15        /// <para>Исходник: https://oeis.org/A000142/list </para>
16        /// </remarks>
17
18        private static readonly ulong[] _factorials =
19        {
20            1, 1, 2, 6, 24, 120, 720, 5040, 40320, 362880, 3628800, 39916800,
21            479001600, 6227020800, 87178291200, 1307674368000, 20922789888000,
22            355687428096000, 6402373705728000, 121645100408832000, 2432902008176640000
23        };
24
25        /// <remarks>
26        /// <para>Source: https://oeis.org/A000108/list </para>
27        /// <para>Исходник: https://oeis.org/A000108/list </para>
28        /// </remarks>
29        private static readonly ulong[] _catalans =
30        {
31            1, 1, 2, 5, 14, 42, 132, 429, 1430, 4862, 16796, 58786, 208012,
32            742900, 2674440, 9694845, 35357670, 129644790, 477638700, 1767263190,
33            6564120420, 24466267020, 91482563640, 343059613650, 1289904147324,
34            ↪ 4861946401452,

```

```

34         18367353072152, 69533550916004, 263747951750360, 1002242216651368,
35         ↪ 3814986502092304,
36         14544636039226909, 55534064877048198, 212336130412243110, 812944042149730764,
37         ↪ 3116285494907301262, 11959798385860453492
38     };
39
40     public static readonly ulong MaximumFactorialNumber = 20;
41
42     public static readonly ulong MaximumCatalanIndex = 36;
43
44     /// <summary>
45     /// <para>Returns the product of all positive integers less than or equal to the number
46     ↪ specified as an argument.</para>
47     /// <para>Возвращает произведение всех положительных чисел меньше или равных указанному
48     ↪ в качестве аргумента числу.</para>
49     /// </summary>
50     /// <param name="n"><para>The maximum positive number that will participate in
51     ↪ factorial's product.</para><para>Максимальное положительное число, которое будет
52     ↪ участвовать в произведение факториала.</para></param>
53     /// <returns><para>The product of all positive integers less than or equal to the number
54     ↪ specified as an argument.</para><para>Произведение всех положительных чисел меньше
55     ↪ или равных указанному в качестве аргумента числу.</para></returns>
56     public static ulong Factorial(ulong n)
57     {
58         if (n >= 0 && n <= MaximumFactorialNumber)
59         {
60             return _factorials[n];
61         }
62         else
63         {
64             throw new ArgumentOutOfRangeException($"Only numbers from 0 to
65             ↪ {MaximumFactorialNumber} are supported by unsigned integer with 64 bits
66             ↪ length.");
67         }
68     }
69
70     /// <summary>
71     /// <para>Returns the Catalan Number with the number specified as an argument.</para>
72     /// <para>Возвращает Каталановое число с номером указанным в качестве аргумента.</para>
73     /// </summary>
74     /// <param name="n"><para>The number of Catalan number.</para><para>Номер Каталанового
75     ↪ числа.</para></param>
76     /// <returns><para>The Catalan Number with the number specified as an
77     ↪ argument.</para><para>Каталановое число с номером указанным в качестве
78     ↪ аргумента.</para></returns>
79     public static ulong Catalan(ulong n)
80     {
81         if (n >= 0 && n <= MaximumCatalanIndex)
82         {
83             return _catalans[n];
84         }
85         else
86         {
87             throw new ArgumentOutOfRangeException($"Only numbers from 0 to
88             ↪ {MaximumCatalanIndex} are supported by unsigned integer with 64 bits
89             ↪ length.");
90         }
91     }
92
93     [MethodImpl(MethodImplOptions.AggressiveInlining)]
94     public static bool IsPowerOfTwo(ulong x) => (x & x - 1) == 0;
95
96     [MethodImpl(MethodImplOptions.AggressiveInlining)]
97     public static T Abs<T>(T x) => Math<T>.Abs(x);
98
99     [MethodImpl(MethodImplOptions.AggressiveInlining)]
100    public static T Negate<T>(T x) => Math<T>.Negate(x);
101
102 }

```

1.8 ./csharp/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     /// <summary>

```

```

8  /// <para>Provides a set of extension methods that perform mathematical operations on
   ↳ arbitrary object types.</para>
9  /// <para>Предоставляет набор методов расширения выполняющих математические операции для
   ↳ объектов произвольного типа.</para>
10 /// </summary>
11 public static class MathExtensions
12 {
13     /// <summary>
14     /// <para>Takes a module from a number.</para>
15     /// <para>Берёт модуль от числа.</para>
16     /// </summary>
17     /// <param name = "x">
18     /// <para>The number from which to take the absolute value.</para>
19     /// <para>Число от которого необходимо взять абсолютное значение.</para>
20     /// </param>
21     /// <returns>
22     /// <para>The absolute value of a number.</para>
23     /// <para>Абсолютное значение числа.</para>
24     /// </returns>
25     [MethodImpl(MethodImplOptions.AggressiveInlining)]
26     public static T Abs<T>(this ref T x) where T : struct => x = Math<T>.Abs(x);
27
28     /// <summary>
29     /// <para>Makes a number negative.</para>
30     /// <para>Делает число отрицательным.</para>
31     /// </summary>
32     /// <param name = "x">
33     /// <para>The number to be made negative.</para>
34     /// <para>Число которое нужно сделать отрицательным.</para>
35     /// </param>
36     /// <returns>
37     /// <para>Negative number.</para>
38     /// <para>Отрицательное число.</para>
39     /// </returns>
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     public static T Negate<T>(this ref T x) where T : struct => x = Math<T>.Negate(x);
42 }
43 }

```

1.9 ./csharp/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 }

```

```

40     }
41 }
42 }

```

1.10 ./csharp/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 }

```

1.11 ./csharp/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.Equal(3, Arithmetic.Add(1, 2));
12             Assert.Equal(1, Arithmetic.Subtract(2, 1));
13             Assert.Equal(8, Arithmetic.Multiply(2, 4));
14             Assert.Equal(4, Arithmetic.Divide(8, 2));
15             Assert.Equal(2, Arithmetic.Increment(1));
16             Assert.Equal(1UL, Arithmetic.Decrement(2UL));
17             Assert.Throws<NotSupportedException>(() => Arithmetic<string>.Subtract("1", "2"));
18         }
19     }
20 }

```

1.12 ./csharp/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         }
26     }
27 }

```

```

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 & 0xFFFFFFF0) >> 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 }

```

1.13 ./csharp/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 }
```

1.14 ./csharp/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 }
```

1.15 ./csharp/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 }

```

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