

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> Each function performs the simplest arithmetic operation on the type specified as
9      ///     ↪ a parameter </para>
10     /// <para> Каждая функция выполняет простейшую арифметическую операцию над типом, указанным
11     ///     ↪ в качестве параметра </para>
12     /// </summary>
13     public static class Arithmetic
14     {
15         /// <summary>
16         /// <para> Adding the x and y arguments </para>
17         /// <para> Сложение аргументов x и y </para>
18         /// </summary>
19         /// <returns>
20         /// <para> Sum of x and y </para>
21         /// <para> Сумма x и y </para>
22         /// </returns>
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public static T Add<T>(T x, T y) => Arithmetic<T>.Add(x, y);
25
26         /// <summary>
27         /// <para> Subtracting x from y </para>
28         /// <para> Вычитание x из y </para>
29         /// </summary>
30         /// <returns>
31         /// <para> Difference of x and y </para>
32         /// <para> Разность x и y </para>
33         /// </returns>
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public static T Subtract<T>(T x, T y) => Arithmetic<T>.Subtract(x, y);
36
37         /// <summary>
38         /// <para> Multiplication the x and y </para>
39         /// <para> Умножение x и y </para>
40         /// </summary>
41         /// <returns>
42         /// <para> Product of x and y </para>
43         /// <para> Произведение x и y </para>
44         /// </returns>
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public static T Multiply<T>(T x, T y) => Arithmetic<T>.Multiply(x, y);
47
48         /// <summary>
49         /// <para> Dividing x by y </para>
50         /// <para> Деление x на y </para>
51         /// </summary>
52         /// <returns>
53         /// <para> Quoitent of x and y </para>
54         /// <para> Частное x и y </para>
55         /// </returns>
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]
57         public static T Divide<T>(T x, T y) => Arithmetic<T>.Divide(x, y);
58
59         /// <summary>
60         /// <para> Increasing the parameter x by one </para>
61         /// <para> Увеличение параметра x на единицу </para>
62         /// </summary>
63         /// <returns>
64         /// <para> Increase by one x </para>
65         /// <para> Увеличенное на единицу x </para>
66         /// </returns>
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         public static T Increment<T>(T x) => Arithmetic<T>.Increment(x);
69
70         /// <summary>
71         /// <para> Increase the parameter x passed by reference by one </para>
72         /// <para> Увеличение переданного по ссылке параметра x на единицу </para>
73         /// </summary>
74         /// </returns>
```

```

75     /// <para> Increase by one x with returning the value to the original variable </para>
76     /// <para> Увеличенное на единицу x с возвратом значения в исходную переменную </para>
77     /// </returns>
78     [MethodImpl(MethodImplOptions.AggressiveInlining)]
79     public static T Increment<T>(ref T x) => x = Arithmetic<T>.Increment(x);
80
81     /// <summary>
82     /// <para> Decrease parameter x by one </para>
83     /// <para> Уменьшение параметра x на единицу </para>
84     /// </summary>
85     /// <returns>
86     /// <para> Reduced by one x </para>
87     /// <para> Уменьшенное на единицу x </para>
88     /// </returns>
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     public static T Decrement<T>(T x) => Arithmetic<T>.Decrement(x);
91
92     /// <summary>
93     /// <para> Decreasing the parameter x passed by reference by one </para>
94     /// <para> Уменьшение переданного по ссылке параметра x на единицу </para>
95     /// </summary>
96     /// <returns>
97     /// <para> Reduced by one x with returning the value to the original variable </para>
98     /// <para> Уменьшенное на единицу x с возвратом значения в исходную переменную </para>
99     /// </returns>
100    [MethodImpl(MethodImplOptions.AggressiveInlining)]
101    public static T Decrement<T>(ref T x) => x = Arithmetic<T>.Decrement(x);
102    }
103 }

```

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 =
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 ./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 }

```

```

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
10     public static class Bit
11     {
12         /// <summary>
13         /// <para> Counts the number of bits set in a number </para>
14         /// <para> Подсчитывает количество установленных бит в числе </para>
15         /// </summary>
16         /// <returns>
17         /// <para> Number of bits set in a number </para>
18         /// <para> Количество установленных бит в числе </para>
19         /// </returns>
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public static long Count(long x)
22         {
23             long n = 0;
24             while (x != 0)
25             {
26                 n++;
27                 x &= x - 1;
28             }
29             return n;
30         }
31         /// <summary>
32         /// <para> Searches for the first bit set in a number </para>
33         /// <para> Ищет первый установленный бит в числе </para>
34         /// </summary>
35         /// <returns>
36         /// <para> First bit set </para>
37         /// <para> Первый установленный бит </para>
38         /// </returns>
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         public static int GetLowestPosition(ulong value)
41         {
42             if (value == 0)
43             {
44                 return -1;
45             }
46             var position = 0;
47             while ((value & 1UL) == 0)
48             {
49                 value >>= 1;
50                 ++position;
51             }
52             return position;
53         }
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         public static T Not<T>(T x) => Bit<T>.Not(x);
57
58         [MethodImpl(MethodImplOptions.AggressiveInlining)]
59         public static T Or<T>(T x, T y) => Bit<T>.Or(x, y);
60
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         public static T And<T>(T x, T y) => Bit<T>.And(x, y);
63
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]
65         public static T ShiftLeft<T>(T x, int y) => Bit<T>.ShiftLeft(x, y);
66
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         public static T ShiftRight<T>(T x, int y) => Bit<T>.ShiftRight(x, y);
69
70         [MethodImpl(MethodImplOptions.AggressiveInlining)]
71         public static T PartialWrite<T>(T target, T source, int shift, int limit) =>
72             ↪ Bit<T>.PartialWrite(target, source, shift, limit);
73
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]
75         public static T PartialRead<T>(T target, int shift, int limit) =>
76             ↪ Bit<T>.PartialRead(target, shift, limit);
77     }
78 }

```

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        [MethodImpl(MethodImplOptions.AggressiveInlining)]
15        public static T Not<T>(this ref T target) where T : struct => target = Bit.Not(target);
16
17        [MethodImpl(MethodImplOptions.AggressiveInlining)]
18        public static T PartialWrite<T>(this ref T target, T source, int shift, int limit) where
19            ↪ T : struct => target = Bit<T>.PartialWrite(target, source, shift, limit);
20
21        [MethodImpl(MethodImplOptions.AggressiveInlining)]
22        public static T PartialRead<T>(this T target, int shift, int limit) =>
23            ↪ Bit<T>.PartialRead(target, shift, limit);
24    }

```

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         [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         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         private static Func<T, T, T> CompileAndDelegate()
46         {
47             return DelegateHelpers.Compile<Func<T, T, T>>(emitter =>
48             {
49                 Ensure.Always.IsNumeric<T>();
50                 emitter.LoadArguments(0, 1);
51                 emitter.And();
52                 emitter.Return();
53             });
54
55     }

```

```

56 [MethodImpl(MethodImplOptions.AggressiveInlining)]
57 private static Func<T, int, T> CompileShiftLeftDelegate()
58 {
59     return DelegateHelpers.Compile<Func<T, int, T>>(emitter =>
60     {
61         Ensure.Always.IsNumeric<T>();
62         emitter.LoadArguments(0, 1);
63         emitter.ShiftLeft();
64         emitter.Return();
65     });
66 }
67
68 [MethodImpl(MethodImplOptions.AggressiveInlining)]
69 private static Func<T, int, T> CompileShiftRightDelegate()
70 {
71     return DelegateHelpers.Compile<Func<T, int, T>>(emitter =>
72     {
73         Ensure.Always.IsNumeric<T>();
74         emitter.LoadArguments(0, 1);
75         emitter.ShiftRight();
76         emitter.Return();
77     });
78 }
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 private static Func<T, T, int, int, T> CompilePartialWriteDelegate()
82 {
83     return DelegateHelpers.Compile<Func<T, T, int, int, T>>(emitter =>
84     {
85         Ensure.Always.IsNumeric<T>();
86         var constants = GetConstants();
87         var bitsNumber = constants.Item1;
88         var numberFilledWithOnes = constants.Item2;
89         ushort shiftArgument = 2;
90         ushort limitArgument = 3;
91         var checkLimit = emitter.DefineLabel();
92         var calculateSourceMask = emitter.DefineLabel();
93         // Check shift
94         emitter.LoadArgument(shiftArgument);
95         emitter.LoadConstant(0);
96         emitter.BranchIfGreaterOrEqual(checkLimit); // Skip fix
97         // Fix shift
98         emitter.LoadConstant(bitsNumber);
99         emitter.LoadArgument(shiftArgument);
100        emitter.Add();
101        emitter.StoreArgument(shiftArgument);
102        emitter.MarkLabel(checkLimit);
103        // Check limit
104        emitter.LoadArgument(limitArgument);
105        emitter.LoadConstant(0);
106        emitter.BranchIfGreaterOrEqual(calculateSourceMask); // Skip fix
107        // Fix limit
108        emitter.LoadConstant(bitsNumber);
109        emitter.LoadArgument(limitArgument);
110        emitter.Add();
111        emitter.StoreArgument(limitArgument);
112        emitter.MarkLabel(calculateSourceMask);
113        var sourceMask = emitter.DeclareLocal<T>();
114        var targetMask = emitter.DeclareLocal<T>();
115        emitter.LoadConstant(typeof(T), numberFilledWithOnes);
116        emitter.LoadArgument(limitArgument);
117        emitter.ShiftLeft();
118        emitter.Not();
119        emitter.LoadConstant(typeof(T), numberFilledWithOnes);
120        emitter.And();
121        emitter.StoreLocal(sourceMask);
122        emitter.LoadLocal(sourceMask);
123        emitter.LoadArgument(shiftArgument);
124        emitter.ShiftLeft();
125        emitter.Not();
126        emitter.StoreLocal(targetMask);
127        emitter.LoadArgument(0); // target
128        emitter.LoadLocal(targetMask);
129        emitter.And();
130        emitter.LoadArgument(1); // source
131        emitter.LoadLocal(sourceMask);
132        emitter.And();
133    });

```

```

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>Источник: 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>Источник: 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,
35             18367353072152, 69533550916004, 263747951750360, 1002242216651368,
36             ↪ 3814986502092304,
37             14544636039226909, 55534064877048198, 212336130412243110, 812944042149730764,
38             ↪ 3116285494907301262, 11959798385860453492
39         };
40
41         public static readonly ulong MaximumFactorialNumber = 20;
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 }

```



```

59
60     /// <summary>
61     /// <para>Returns the Catalan Number with the number specified as an argument.</para>
62     /// <para>Возвращает Каталановое число с номером указанным в качестве аргумента.</para>
63     /// </summary>
64     /// <param name="n"><para>The number of Catalan number.</para><para>Номер Каталанового
    ↪ числа.</para></param>
65     /// <returns><para>The Catalan Number with the number specified as an
    ↪ argument.</para><para>Каталановое число с номером указанным в качестве
    ↪ аргумента.</para></returns>
66     public static ulong Catalan(ulong n)
67     {
68         if (n >= 0 && n <= MaximumCatalanIndex)
69         {
70             return _catalans[n];
71         }
72         else
73         {
74             throw new ArgumentOutOfRangeException($"Only numbers from 0 to
    ↪ {MaximumCatalanIndex} are supported by unsigned integer with 64 bits
    ↪ length.");
75         }
76     }
77
78     [MethodImpl(MethodImplOptions.AggressiveInlining)]
79     public static bool IsPowerOfTwo(ulong x) => (x & x - 1) == 0;
80
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     public static T Abs<T>(T x) => Math<T>.Abs(x);
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     public static T Negate<T>(T x) => Math<T>.Negate(x);
86 }
87 }

```

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      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 }

```

1.9 ./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 }

```

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     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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