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**Information technology — Common  
Language Infrastructure (CLI) —  
Technical Report: Common Generics**

*Technologies de l'information — Infrastructure commune de  
langage (ICL) — Rapport technique: Génériques communs*

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## Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 25438 was prepared by Ecma International (as Ecma TR/89) and was adopted, under a special "fast-track procedure", by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

## Introduction

This Technical Report defines a collection of types that are intended to enhance the common language nature of the CLI, by facilitating language inter-operation. The collection includes generic tuples, functions, actions, optional value representation, a type that can contain a value of one of two different types, and a utility filler type.

These types are experimental and will be considered for inclusion in a future version of the CLI International Standard. A reference implementation, written in C#, is included (see the accompanying file `CommonGenericsLibrary.cs`). This implementation source is also available from <http://kahu.zoot.net.nz/ecma>. A binary version is also available from that site, along with any updates to the proposal.

Feedback on these types is encouraged. (Please send comments to [ecmacli@zoot.net.nz](mailto:ecmacli@zoot.net.nz).)

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# Information technology — Common Language Infrastructure (CLI) — Technical Report: Common Generics

## 1 Scope

The CLI standard libraries (ISO/IEC 23271) provide a collection of common types that can be used by multiple languages. With the addition of generics to the CLI, the standard libraries have been extended to include a number of common generic types, in particular, collections. However, at present, these libraries do not include many simple generic types found in a number of different languages. Any language which uses these common types must implement them rather than deferring to the CLI library, thereby reducing language interoperability. This Technical Report addresses this issue by providing a number of these common types.

Generic tuples (product types) are standard in a number of languages: C++ (`template Pair`), Ada, Haskell, and Standard ML (SML). However, languages differ in the number of pre-defined tuple sizes supported by their standard libraries; e.g. C++ provides just one (`Pair`) while Haskell provides eight (sizes 2 to 9) and SML allows any size of tuple. This Technical Report provides nine (sizes 2 to 10).

Generic programming encourages “higher order” programming where generic functions (methods) take function (delegate) type arguments that have generic types. Examples include Ada’s `with` and generic constraints, and function arguments in Haskell and SML. In the CLI, function values are provided in the form of delegates, so this proposal defines standard generic delegate types for functions (which return a value) and procedures (which do not).

Another two types that occur in a number of languages are an *optional* type, which either contains a value of some other type or an indication that such a value is not present; and an *either* type, which holds a value of one of two possible types and an indication of which one is present. This proposal provides both of these.

Note The optional type is similar to, but different from, the type `System.Nullable`.

Finally, in existing generic languages, a need has been found for a *filler* type to be used when a particular generic parameter is not required for a particular use of the generic type. A standard one-value type is often provided for this purpose, often called `Unit` or `Void`. This Technical Report includes such a type.

## 2 Rationale

### 2.1 Reference vs. value tuples

In some languages (such as C++ and Ada) tuple types can be value or reference types, while in others (such as Haskell and SML) they are always reference types. This implementation provides only value type tuples (which can contain value or reference types). Boxed versions of these types can be used when reference versions are required. Named boxed types would, of course, help greatly here, but these are not currently provided by the CLI Standard.

A simple generic type, such as `Boxed<T>`, can be written to address this issue. Such a type has been made available in the reference implementation of this proposal. However it is not being considered for standardization at this time.

## 2.2 Interaction with other standard types

The CLI Standard contains six types related to those in this proposal. These are:

**System.Action<T>**: This type is just the first member of this collection's set of action types. As it is already standardized it is not included here.

**System.Comparison<T>**: This type is equivalent to this collection's `Function<T, T, Int32>`. Conversion methods are provided.

**System.Converter<T,U>**: This type is equivalent to this collection's `Function<T, U>`. Conversion methods are provided.

**System.Nullable<T>**: This type is a restricted version of this collection's `Optional<T>`. The difference is that `Nullable<T>` is restricted to non-nullable value types, whereas `Optional<T>` can also wrap reference types and nullable value types. Both these choices are useful in different applications, so there is no clash between these two types. This proposal includes operators on the `Optional<T>` type to convert to/from `Nullable<T>` values.

**System.Predicate<T>**: This type is equivalent to this collection's `Function<T, Boolean>`. However as the CLI does not support type synonyms, these two types are (unfortunately) not equivalent. A separate static class provides methods to convert between these two types. The methods are in a separate class as additional methods cannot be declared on delegate types.

**System.Collections.Generic.KeyValuePair<K,V>**: This is just a differently named equivalent of this collection's `Tuple<K,V>`. Conversion operators are provided on `Tuple<K,V>` to convert to/from `KeyValuePair<K,V>`.

## 3 Overview

### 3.1 Tuple types

Tuples are provided as value types with public fields, which mirrors their typical usage in current languages. Overloading on arity is leveraged to provide eight standard tuple types.

The fields are named `ItemA`, `ItemB`, ..., `ItemI`. A single n-ary constructor is provided to easily define all fields.

An `Equals()` method is provided and defined as the component fields being equal according to their `Equals()` methods.

The corresponding `GetHashCode()` method and `op_Equality` and `op_Inequality` methods are provided.

`ToString()` is overridden to provide the typical tuple parenthesized notation.

For tuples of size 2, methods are provided to convert to/from values of type `System.Collections.Generic.KeyValuePair<K, V>`.

### 3.2 Function and procedure types

Standard delegates are provided for function types (`System.Function<>`) and procedures (`System.Action<>`). Delegates are defined for 0 to 5 argument functions and 0 and 2 to 5 argument procedures. (The single argument procedure is already included in the CLI Standard.)

### 3.3 Unit

The `Unit` type is a filler type. This is useful, for example, when an existing generic type is used, but one of its type arguments is not required for the particular application.

### 3.4 Optional

The `Optional<A>` type represents either a value of type A, or the lack of a value. A value of this type is immutable and provides two constructors, one providing a value, the other for providing no value. Properties are provided to test for validity and to obtain the value. An exception is thrown if an attempt to access a non-existent value.

### 3.5 Either

The `Either<A, B>` type represents either a value of type A, or a value of type B. A value of this type is immutable. Properties are provided to test which type of value is present and to obtain the value. An exception is thrown if an attempt to access the value of one type is made when a value of the other type is present.

## 4 Action delegates

### 4.1 System.Action delegate

```
[ILAsm]
.class public auto ansi sealed System.Action
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance void Invoke()
}

[C#]
public delegate void Action();
```

#### Assembly Info:

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - `CLSCompliantAttribute(true)`

#### Implements:

- `System.ICloneable`

**Summary:**

Represents a method that performs an action.

**Parameters:**

**Inherits From:** `System.Delegate`

**Library:** BCL

**Description**

A generic delegate type for zero-argument, methods which perform an action (return void).

## 4.2 `System.Action<A, B>` delegate

```
[ILAsm]
.class public auto ansi sealed System.Action`2<A, B>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance void Invoke(!0 argA,
                             !1 argB)
}

[C#]
public delegate void Action<A, B>
    (A argA,
     B argB
    );
```

**Assembly Info:**

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - `CLSCompliantAttribute(true)`

**Implements:**

- `System.ICloneable`

**Summary:**

Represents a method that performs an action using the supplied arguments.

**Parameters:**

| Parameter   | Description                        |
|-------------|------------------------------------|
| <i>argA</i> | The first argument to the action.  |
| <i>argB</i> | The second argument to the action. |

**Inherits From:** `System.Delegate`

**Library:** BCL

**Description**

A generic delegate type for two-argument methods, which perform an action (return void).

**4.3 System.Action<A, B, C> delegate**

```
[ILAsm]
.class public auto ansi sealed System.Action`3<A, B, C>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance void Invoke(!0 argA,
                             !1 argB,
                             !2 argC)
}

[C#]
public delegate void Action<A, B, C>
    (A argA,
     B argB,
     C argC
    );
```

**Assembly Info:**

- *Name:*
- *Public Key:*
- *Version:*

- *Attributes:*
  - CLSCompliantAttribute(true)

**Implements:**

- System.ICloneable

**Summary:**

Represents a method that performs an action using the supplied arguments.

**Parameters:**

| Parameter   | Description                        |
|-------------|------------------------------------|
| <i>argA</i> | The first argument to the action.  |
| <i>argB</i> | The second argument to the action. |
| <i>argC</i> | The third argument to the action.  |

**Inherits From:** System.Delegate

**Library:** BCL

**Description**

A generic delegate type for three-argument methods, which perform an action (return void).

**4.4 System.Action<A, B, C, D> delegate**

```

[ILAsm]
.class public auto ansi sealed System.Action`4<A, B, C, D>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance void Invoke(!0 argA,
                             !1 argB,
                             !2 argC,
                             !3 argD)
}

[C#]
public delegate void Action<A, B, C, D>
    (A argA,
     B argB,
     C argC,
     D argD
    );

```

**Assembly Info:**

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - CLSCompliantAttribute(true)

**Implements:**

- `System.ICloneable`

**Summary:**

Represents a method that performs an action using the supplied arguments.

**Parameters:**

| Parameter   | Description                        |
|-------------|------------------------------------|
| <i>argA</i> | The first argument to the action.  |
| <i>argB</i> | The second argument to the action. |
| <i>argC</i> | The third argument to the action.  |
| <i>argD</i> | The fourth argument to the action. |

**Inherits From:** `System.Delegate`

**Library:** BCL

**Description**

A generic delegate type for four-argument methods, which perform an action (return void).

#### 4.5 System.Action<A, B, C, D, E> delegate

```
[ILAsm]
.class public auto ansi sealed System.Action`5<A, B, C, D, E>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance void Invoke(!0 argA,
                               !1 argB,
                               !2 argC,
                               !3 argD,
                               !4 argE)
}

[C#]
public delegate void Action<A, B, C, D, E>
    (A argA,
     B argB,
     C argC,
     D argD,
     E argE
    );
```

##### Assembly Info:

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - CLSCompliantAttribute(true)

##### Implements:

- System.ICloneable

##### Summary:

Represents a method that performs an action using the supplied arguments.

**Parameters:**

| Parameter   | Description                        |
|-------------|------------------------------------|
| <i>argA</i> | The first argument to the action.  |
| <i>argB</i> | The second argument to the action. |
| <i>argC</i> | The third argument to the action.  |
| <i>argD</i> | The fourth argument to the action. |
| <i>argE</i> | The fifth argument to the action.  |

**Inherits From:** `System.Delegate`

**Library:** BCL

**Description**

A generic delegate type for five-argument methods, which perform an action (return void).

**5 System.DelegateCast class**

```
[ILAsm]
.class public abstract sealed beforefieldinit System.DelegateCast
    extends System.Object

[C#]
public static class DelegateCast
```

**Assembly Info:**

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - CLSCompliantAttribute(true)

Summary

Provides methods for converting between `System.Function<>` and corresponding `System.Predicate<T>`, `System.Converter<T, U>` and `System.Comparison<T>` delegate types.

**Inherits From:** `System.Object`

**Library:**

**Thread Safety:** This type is safe for multithreaded operations.

Description

5.1 `DelegateCast.ToFunction<T, Boolean>(System.Predicate<T>)` method

```
[ILAsm]
.method public hidebysig static class Function`2<!!0, bool>
    ToFunction<T>(class Predicate`1<!!0> pred)

[C#]
public static Function<T, bool> ToFunction<T>(Predicate<T> pred)
```

Summary

Constructs a `System.Function<T, bool>` value equivalent to the given `System.Predicate<T>` value.

Parameters

| Parameter   | Description                                            |
|-------------|--------------------------------------------------------|
| <i>pred</i> | The <code>System.Predicate&lt;T&gt;</code> to convert. |

Return Value

A `System.Function<T, bool>` value, functionally equivalent to the `System.Predicate<T>` argument.

Description

5.2 `DelegateCast.ToPredicate<T>(System.Function<T, System.Boolean>)` method

```
[ILAsm]
.method public hidebysig static class Predicate`1<!!0>
    ToPredicate<T>(class Function`2<!!0, bool> func)

[C#]
public static Predicate<T> ToPredicate<T>(Function<T, bool> func)
```

## Summary

Constructs a `System.Predicate<T>` value equivalent to the given `System.Function<T, Boolean>` value.

## Parameters

| Parameter   | Description                                                 |
|-------------|-------------------------------------------------------------|
| <i>Func</i> | The <code>System.Function&lt;T, bool&gt;</code> to convert. |

## Return Value

A `System.Predicate<T>` value functionally equivalent to the `System.Function<T, bool>` argument.

## Description

### 5.3 DelegateCast.ToFunction<T, U>(System.Converter<T, U>) method

```
[ILAsm]
.method public hidebysig static class Function`2<!!0, !!1>
    ToFunction<T, U>(class Converter`2<!!0, !!1> conv)

[C#]
public static Function<T, U> ToFunction<T, U>(Converter<T, U> conv)
```

## Summary

Constructs a `System.Function<T, U>` value equivalent to the given `System.Converter<T, U>` value.

## Parameters

| Parameter   | Description                                               |
|-------------|-----------------------------------------------------------|
| <i>conv</i> | The <code>System.Converter&lt;T, U&gt;</code> to convert. |

## Return Value

A `System.Function<T, U>` value functionally equivalent to the `System.Converter<T, U>` argument.

## Description

#### 5.4 DelegateCast.ToConverter<T, U>(System.Function<T, U>) method

```
[ILAsm]
.method public hidebysig static class Converter`2<!!0, !!1>
    ToConverter<T, U>(class Function`2<!!0, !!1> func)
```

```
[C#]
public static Converter<T, U> ToConverter<T, U>(Function<T, U> func)
```

##### Summary

Constructs a `System.Converter<T, U>` value equivalent to the given `System.Function<T, U>` value.

##### Parameters

| Parameter   | Description                                              |
|-------------|----------------------------------------------------------|
| <i>func</i> | The <code>System.Function&lt;T, U&gt;</code> to convert. |

##### Return Value

A `System.Converter<T, U>` value functionally equivalent to the `System.Function<T, U>` argument.

##### Description

#### 5.5 DelegateCast.ToFunction<T, T, System.Int32>(System.Comparison<T>) method

```
[ILAsm]
.method public hidebysig static class Function`3<!!0, !!1, int>
    ToFunction<T>(class Comparison`1<!!0> comp)
```

```
[C#]
public static Function<T, T, int> ToFunction<T>(Comparison<T> comp)
```

##### Summary

Constructs a `System.Function<T, T, Int32>` value equivalent to the given `System.Comparison<T>` value.

##### Parameters

| Parameter   | Description                                             |
|-------------|---------------------------------------------------------|
| <i>comp</i> | The <code>System.Comparison&lt;T&gt;</code> to convert. |

**Return Value**

A `System.Function<T, T, System.Int32>` value functionally equivalent to the `System.Comparison<T>` argument.

**Description****5.6 DelegateCast.ToComparison<T>(System.Function<T, T, System.Int32>) method**

```
[ILAsm]
.method public hidebysig static class Comparison`1<!!0>
    ToComparison<T>(class Function`3<!!0,!!1,int> func)

[C#]
public static Comparison<T> ToComparison<T>(Function<T, T, int> func)
```

**Summary**

Constructs a `System.Comparison<T>` value equivalent to the given `System.Function<T, T, Int32>` value.

**Parameters**

| Parameter   | Description                                                     |
|-------------|-----------------------------------------------------------------|
| <i>func</i> | The <code>System.Function&lt;T, T, Int32&gt;</code> to convert. |

**Return Value**

A `System.Comparison<T>` value functionally equivalent to the `System.Function<T, T, Int32>` argument.

**Description****6 System.Either<A, B> Structure**

```
[ILAsm]
.class public sequential serializable sealed Either`2<A, B> extends
    System.ValueType implements IEquatable`1<valuetype Either`2<A, B>>

[C#]
public struct Either<A, B> : IEquatable<Either<A, B>>
```

**Assembly Info:**

- *Name:*
- *Public Key:*

- *Version:*
- *Attributes:*
  - `CLSCompliantAttribute(true)`

**Implements:**

- `System.IEquatable<Either<A, B>>`

**Summary**

Contains a value of type A or a value of type B.

**Inherits From:** `System.ValueType`

**Library:**

**Thread Safety:** This type is not guaranteed to be safe for multithreaded operations.

**Description**

The `System.Either<A, B>` value type represents either a value of a given type A or a value of a given type B. For example, an instance of `System.Either<System.Int32, System.String>` contains either a `System.Int32` value or a `System.String` value. Instances of this type are immutable.

An instance of `System.Either<A, B>` has four key properties; `IsFirst`, `IsSecond`, `First`, and `Second`. `IsFirst` and `IsSecond` are used to determine whether the current instance has a value of type A or a value of a given B. They return `true` or `false`, and never throw an exception. `First` and `Second` return the value of the instance, provided it is of the appropriate type (i.e., `First` or `Second` are `true` respectively); otherwise, they throw an exception.

Calling `System.Either<A, B>.IsFirst` on an instance that has the default initial value returns `true` and calling `System.Either<A, B>.First` returns the default value of type A.

See the methods `System.Either<A, B>.MakeFirst` and `System.Either<A, B>.MakeSecond` for how to create new instances initialized to values of type A or type B respectively.

See also `System.Nullable<T>` (for value types `T`) and `System.Optional<T>` (for all types `T`) that represent either a value of type `T` or the lack of such a value.

## 6.1 Either<A, B>.Equals(System.Object) method

```
[ILAsm]
.method public hidebysig virtual bool Equals(object other)

[C#]
public override bool Equals(object other)
```

### Summary

Determines whether the current instance and the specified System.Object represent the same type and value.

### Parameters

| Parameter    | Description                                           |
|--------------|-------------------------------------------------------|
| <i>other</i> | The System.Object to compare to the current instance. |

### Return Value

The following table defines the conditions under which the return value is true or false:

| Return Value                         | Conditions                                                                          |
|--------------------------------------|-------------------------------------------------------------------------------------|
| false                                | <i>other</i> is null or the current instance and <i>other</i> have different types. |
| false                                | IsFirst is false and <i>other</i> .IsFirst is true.                                 |
| false                                | IsFirst is true and <i>other</i> .IsFirst is false.                                 |
| First.Equals( <i>other</i> .First)   | IsFirst is true and <i>other</i> .IsFirst is true                                   |
| Second.Equals( <i>other</i> .Second) | IsFirst is false and <i>other</i> . IsFirst is false                                |

### Description

[Note: This method overrides System.Object.Equals.]

## 6.2 Either<A, B>.Equals(Either<A, B>) method

```
[ILAsm]
.method public hidebysig virtual bool Equals(valuetype Either`2<A, B> other)

[C#]
public bool Equals(Either<A, B> other)
```

### Summary

Determines whether the current instance and the specified System.Either<A, B> represent the same value.

### Parameters

| Parameter    | Description                                                 |
|--------------|-------------------------------------------------------------|
| <i>other</i> | The System.Either<A, B> to compare to the current instance. |

### Return Value

The following table defines the conditions under which the return value is true or false:

| Return Value                | Conditions                                   |
|-----------------------------|----------------------------------------------|
| false                       | IsFirst is false and other.IsFirst is true.  |
| false                       | IsFirst is true and other.IsFirst is false.  |
| First.Equals(other.First)   | IsFirst is true and other.IsFirst is true    |
| Second.Equals(other.Second) | IsFirst is false and other. IsFirst is false |

### Description

[*Note:* This method implicitly implements the System.IEquatable<Either<A, B>>.Equals method.]

### 6.3 Either<A, B>.First property

```
[ILAsm]
.property !0 First()
{
    .get instance !0 get_First()
}
.method public hidebysig specialname instance !0 get_First()

[C#]
public A First { get; }
```

#### Summary

Gets the value of type A, if any, of the current instance.

#### Property Value

The value of type A of the current instance.

#### Behaviors

If `System.Either<A, B>.IsFirst` is true, the instance contains a value of type A, and `System.Either<A, B>.First` returns that value. If `System.Either<A, B>.IsFirst` is false, the instance has a value of type B, and an attempt to read `System.Either<A, B>.First` results in an exception.

This property is read-only.

#### Exceptions

| Exception                                     | Condition                                                |
|-----------------------------------------------|----------------------------------------------------------|
| <code>System.InvalidOperationException</code> | <code>System.Either&lt;A, B&gt;.IsFirst</code> is false. |

### 6.4 Either<A, B>.GetHashCode() method

```
[ILAsm]
.method public hidebysig virtual int32 GetHashCode()

[C#]
public override int GetHashCode()
```

#### Summary

Generates a hash code for the value of the current instance.

**Return Value**

A `System.Int32` containing the hash code for the value of the current instance is returned.

**Description**

The algorithm used to generate the hash code is unspecified.

[*Note:* This method overrides `System.Object.GetHashCode`.]

**6.5 Either<A, B>.IsFirst property**

```
[ILAsm]
.property bool IsFirst()
{
    .get instance bool get_IsFirst()
}
.method public hidebysig specialname instance bool get_IsFirst()

[C#]
bool IsFirst { get; }
```

**Summary**

Indicates whether the current instance contains a value of type A.

**Property Value**

true if the current instance was constructed by a call to `MakeFirst` or is the default value of `Either<A, B>`; otherwise, false.

**Behaviors**

If `System.Either<A, B>.IsFirst` is true, the instance contains a value of type A, `System.Either<A, B>.First` returns that value, and `System.Either<A, B>.IsSecond` returns false. If `System.Either<A, B>.IsFirst` is false, the instance contains a value of type B, `System.Either<A, B>.IsSecond` returns true, and an attempt to read `System.Either<A, B>.First` results in a `System.InvalidOperationException` exception.

This property is read-only.

## 6.6 Either<A, B>.IsSecond property

```
[ILAsm]
.property bool IsSecond()
{
    .get instance bool get_IsSecond()
}
.method public hidebysig specialname instance bool get_IsSecond()

[C#]
public bool IsSecond { get; }
```

### Summary

Indicates whether the current instance contains a value of type B.

### Property Value

true if the current instance was constructed by a call to `MakeSecond`; otherwise, false.

### Behaviors

If `System.Either<A, B>.IsSecond` is true, the instance contains a value of type B, `System.Either<A, B>.Second` returns that value, and `System.Either<A, B>.IsFirst` returns false. If `System.Either<A, B>.IsSecond` is false, the instance contains a value of type A, `System.Either<A, B>.IsFirst` returns true, and an attempt to read `System.Either<A, B>.Second` results in a `System.InvalidOperationException` exception.

This property is read-only.

## 6.7 Either<A, B>.op\_Equality(Either<A, B>, Either<A, B>) method

```
[ILAsm]
.method public hidebysig specialname static
    bool op_Equality(valuetype Either`2<!0, !1> left,
                    valuetype Either`2<!0, !1> right)

[C#]
public static bool operator==(Either<A, B> left, Either<A, B> right)
```

### Summary

Determines whether the specified values are equal.

**Parameters**

| Parameter    | Description                                                  |
|--------------|--------------------------------------------------------------|
| <i>left</i>  | The first <code>Either&lt;A, B&gt;</code> value to compare.  |
| <i>right</i> | The second <code>Either&lt;A, B&gt;</code> value to compare. |

**Return Value**

The following table defines the conditions under which the return value is `true` or `false`:

| Return Value                                  | Conditions                |                            |
|-----------------------------------------------|---------------------------|----------------------------|
|                                               | <code>left.IsFirst</code> | <code>right.IsFirst</code> |
| <code>left.Second.Equals(right.Second)</code> | false                     | false                      |
| false                                         | false                     | true                       |
| false                                         | true                      | false                      |
| <code>left.First.Equals(right.First)</code>   | true                      | true                       |

**Description****6.8 `Either<A, B>.op_Inequality(Either<A, B>, Either<A, B>)` method**

```
[ILAsm]
.method public hidebysig specialname static
    bool op_Inequality(valuetype Either`2<!0, !1> left,
        valuetype Either`2<!0, !1> right)

[C#]
public static bool operator!=(Either<A, B> left, Either<A, B> right)
```

**Summary**

Determines whether the specified values are not equal.

**Parameters**

| Parameter    | Description                                                  |
|--------------|--------------------------------------------------------------|
| <i>left</i>  | The first <code>Either&lt;A, B&gt;</code> value to compare.  |
| <i>right</i> | The second <code>Either&lt;A, B&gt;</code> value to compare. |

## Return Value

The following table defines the conditions under which the return value is `true` or `false`:

| Return Value                                      | Conditions   |               |
|---------------------------------------------------|--------------|---------------|
|                                                   | left.IsFirst | right.IsFirst |
| <code>Not left.Second.Equals(right.Second)</code> | false        | false         |
| <code>true</code>                                 | false        | true          |
| <code>true</code>                                 | true         | false         |
| <code>Not left.First.Equals(right.First)</code>   | true         | true          |

## Description

### 6.9 Either<A, B>.Second property

```
[ILAsm]
.property !1 Second()
{
    .get instance !1 get_Second()
}
.method public hidebysig specialname instance !1 get_Second()

[C#]
public B Second { get; }
```

## Summary

Gets the value of type B, if any, of the current instance.

## Property Value

The value of type B of the current instance.

## Behaviors

If `System.Either<A, B>.IsSecond` is `true`, the instance contains a value of type B, and `System.Either<A, B>.Second` returns that value. If `System.Either<A, B>.IsSecond` is `false`, the instance has a value of type A, and an attempt to read `System.Either<A, B>.Second` results in an exception.

This property is read-only.

## Exceptions

| Exception                        | Condition                              |
|----------------------------------|----------------------------------------|
| System.InvalidOperationException | System.Either<A, B>.IsSecond is false. |

### 6.10 Either<A, B>.MakeFirst(A aValue) method

```
[ILAsm]
public hidebysig static valuetype Either`<!0, !1>MakeFirst(!0 aValue)

[C#]
public static Either<A, B> MakeFirst(A aValue)
```

## Summary

Constructs and initializes a new instance of `System.Either<A, B>` containing the specified value of type A.

## Parameters

| Parameter     | Description                     |
|---------------|---------------------------------|
| <i>aValue</i> | The value for the new instance. |

## Description

Constructs a new instance of `System.Either<A, B>` containing the supplied value of type A. Once this constructor has executed, applying `System.Either<A, B>.IsFirst` to the new instance returns `true` and applying `System.Either<A, B>.IsSecond` to the new instance returns `false`.

### 6.11 Either<A, B>.MakeSecond(B bValue) method

```
[ILAsm]
public hidebysig static valuetype Either`<!0, !1>MakeSecond(!1 bValue)

[C#]
public static Either<A, B> MakeSecond(B bValue)
```

## Summary

Constructs and initializes a new instance of `System.Either<A, B>` containing the specified value of type B.

**Parameters**

| Parameter     | Description                     |
|---------------|---------------------------------|
| <i>bValue</i> | The value for the new instance. |

**Description**

Constructs a new instance of `System.Either<A, B>` containing the supplied value of type B. Once this constructor has executed, applying `System.Either<A, B>.IsSecond` to the new instance returns `true`.

**6.12 Either<A, B>.ToString() method**

```
[ILAsm]
.method public hidebysig virtual string ToString()

[C#]
public override string ToString()
```

**Summary**

Returns a `System.String` representation of the value of the current instance.

**Return Value**

If `System.Either<A, B>.IsFirst` is `true`, `System.Either<A, B>.First.ToString()` is returned; otherwise, `System.Either<A, B>.Second.ToString()` is returned.

**Description**

[Note: This method overrides `System.Object.ToString`.]

**6.13 Either<A, B>(A) constructor**

```
[ILAsm]
public rtspecialname specialname instance void .ctor(A aValue)

[C#]
public Either(A aValue)
```

**Attributes**

- `CLSCompliantAttribute(false)`

## Summary

Constructs and initializes a new instance of `System.Either<A, B>` which contains the given value of type A.

## Description

Constructs a new instance of `System.Either<A, B>`. Once this constructor has executed, calling `System.Either<A, B>.IsFirst` on the new instance returns `true` and calling `System.Either<A, B>.First` returns the given value of type A.

[Note: If the type A is the same as the type B then this method unifies with the constructor which accepts a value of type B; therefore this method is not CLS-compliant and is marked as such.]

[Note: The construction implemented by this method corresponds exactly to calling the `System.Either<A, B>.MakeFirst` method.]

### 6.14 Either<A, B>(B) constructor

```
[ILAsm]
public rtspecialname specialname instance void .ctor(B bValue)

[C#]
public Either(B bValue)
```

## Attributes

- `CLSCompliantAttribute(false)`

## Summary

Constructs and initializes a new instance of `System.Either<A, B>` which contains the given value of type B.

## Description

Constructs a new instance of `System.Either<A, B>`. Once this constructor has executed, calling `System.Either<A, B>.IsSecond` on the new instance returns `true` and calling `System.Either<A, B>.Second` returns the given value of type B.

[Note: If the type A is the same as the type B then this method unifies with the constructor which accepts a value of type A; therefore this method is not CLS-compliant and is marked as such.]

[Note: The construction implemented by this method corresponds exactly to calling the `System.Either<A, B>.MakeSecond` method.]

## 6.15 A Either<A, B>.op\_Explicit(System.Either<A, B>) method

```
[ILAsm]
.method public hidebysig static specialname !0 op_Explicit(valuetype
Either`2<!0, !1> abValue)

[C#]
public static explicit operator A(Either<A, B> abValue)
```

### Attributes

- CLSCompliantAttribute(false)

### Summary

Perform an explicit conversion of a `System.Either<A, B>` value to type `A`.

### Parameters

| Parameter      | Description                                                                          |
|----------------|--------------------------------------------------------------------------------------|
| <i>abValue</i> | The <code>System.Either&lt;A, B&gt;</code> value to convert to type <code>A</code> . |

### Return Value

The value of type `A`, if any, of the specified value. Otherwise, an exception is thrown.

### Description

An explicit conversion from a value of type `System.Either<A, B>` to a value of type `A`. If `System.Either<A, B>.IsFirst` is true the value is returned, otherwise an exception is thrown.

[Note: If the type `A` is the same as the type `B` then this method unifies with the `op_Explicit` which returns a value of type `B`, therefore this method is not CLS-compliant and is marked as such.]

[Note: The conversion implemented by this method corresponds exactly to obtaining the value of the `System.Either<A, B>.First` property.]

### Exceptions

| Exception                                     | Condition                                                |
|-----------------------------------------------|----------------------------------------------------------|
| <code>System.InvalidOperationException</code> | <code>System.Either&lt;A, B&gt;.IsFirst</code> is false. |

## 6.16 B Either<A, B>.op\_Explicit(System.Either<A, B>) method

```
[ILAsm]
.method public hidebysig static specialname !1 op_Explicit(valuetype
Either`2<!0, !1> abValue)

[C#]
public static explicit operator B(Either<A, B> abValue)
```

### Attributes

- CLSCompliantAttribute(false)

### Summary

Perform an explicit conversion of a `System.Either<A, B>` value to type B.

### Parameters

| Parameter      | Description                                                            |
|----------------|------------------------------------------------------------------------|
| <i>abValue</i> | The <code>System.Either&lt;A, B&gt;</code> value to convert to type B. |

### Return Value

The value of type B, if any, of the specified value. Otherwise, an exception is thrown.

### Description

An explicit conversion from a value of type `System.Either<A, B>` to a value of type B. If `System.Either<A, B>.IsFirst` is true the value is returned otherwise an exception is thrown.

[Note: If the type A is the same as the type B then this method unifies with the `op_Explicit` which returns a value of type A, therefore this method is not CLS-compliant and is marked as such.]

[Note: The conversion implemented by this method corresponds exactly to obtaining the value of the `System.Either<A, B>.Second` property.]

### Exceptions

| Exception                                     | Condition                                                 |
|-----------------------------------------------|-----------------------------------------------------------|
| <code>System.InvalidOperationException</code> | <code>System.Either&lt;A, B&gt;.IsSecond</code> is false. |

## 6.17 Either<A, B>.op\_Implicit(A) method

```
[ILAsm]
.method public hidebysig static specialname valuetype Either`2<!0, !1>
op_Implicit(!0 aValue)

[C#]
public static implicit operator Either<A, B>(A aValue)
```

### Attributes

- CLSCompliantAttribute(false)

### Summary

Perform an implicit conversion of a value of type A to a value of type `System.Either<A, B>`.

### Parameters

| Parameter     | Description                                                        |
|---------------|--------------------------------------------------------------------|
| <i>aValue</i> | The A value to convert to <code>System.Either&lt;A, B&gt;</code> . |

### Return Value

A `System.Either<A, B>` with the specified value of type A.

### Description

Perform a conversion from *aValue* to a value of type `System.Either<A, B>`. Calling `System.Either<A, B>.IsFirst` on the returned value returns `true`, and `System.Either<A, B>.First` returns the value.

[Note: If the type A is the same as the type B then this method unifies with the `op_Implicit` which takes a value of type B, therefore this method is not CLS-compliant and is marked as such.]

[Note: The conversion implemented by this method corresponds exactly to invoking the `System.Either<A, B>.MakeFirst(A)` method.]

## 6.18 Either<A, B>.op\_Implicit(B) method

```
[ILAsm]
.method public hidebysig static specialname valuetype Either`2<!0, !1>
op_Implicit(!1 bValue)
```

```
[C#]
public static implicit operator Either<A, B>(B bValue)
```

### Attributes

- CLSCompliantAttribute(false)

### Summary

Perform an implicit conversion of a value of type B to a value of type `System.Either<A, B>`.

### Parameters

| Parameter     | Description                                                        |
|---------------|--------------------------------------------------------------------|
| <i>bValue</i> | The B value to convert to <code>System.Either&lt;A, B&gt;</code> . |

### Return Value

A `System.Either<A, B>` with the specified value of type B.

### Description

Perform a conversion from *bValue* to a value of type `System.Either<A, B>`. Calling `System.Either<A, B>.IsSecond` on the returned value returns `true`, and `System.Either<A, B>.Second` returns the value.

[Note: If the type A is the same as the type B then this method unifies with the `op_Implicit` which takes a value of type A, therefore this method is not CLS-compliant and is marked as such.]

[Note: The conversion implemented by this method corresponds exactly to invoking the `System.Either<A, B>.MakeSecond(B)` method.]

## 7 Function Delegates

### 7.1 System.Function<A> delegate

```
[ILAsm]
.class public auto ansi sealed System.Function`1<A>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance !0 Invoke()
}

[C#]
public delegate A Function<A>();
```

#### Assembly Info:

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - CLSCompliantAttribute(true)

#### Implements:

- System.ICloneable

#### Summary:

Represents a method that returns a value.

#### Parameters:

**Inherits From:** System.Delegate

**Library:** BCL

Description

A generic delegate type for zero-argument methods, which perform a function (return a value).

7.2 System.Function<A, B> delegate

```
[ILAsm]
.class public auto ansi sealed System.Function`2<A, B>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance !1 Invoke(!0 argA)
}

[C#]
public delegate B Function<A, B>
    (A argA
    );
```

Assembly Info:

- Name:
- Public Key:
- Version:
- Attributes:
  - CLSCompliantAttribute(true)

Implements:

- System.ICloneable

Summary:

Represents a method that performs a function using the supplied argument.

Parameters:

| Parameter | Description                   |
|-----------|-------------------------------|
| argA      | The argument to the function. |

**Inherits From:** `System.Delegate`

**Library:** BCL

### Description

A generic delegate type for one-argument methods, which perform a function (return a value).

### 7.3 `System.Function<A, B, C>` delegate

```
[ILAsm]
.class public auto ansi sealed System.Function`3<A, B, C>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance !2 Invoke(!0 argA,
                           !1 argB)
}

[C#]
public delegate C Function<A, B, C>
    (A argA,
     B argB
    );
```

### Assembly Info:

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - `CLSCompliantAttribute(true)`

### Implements:

- `System.ICloneable`

### Summary:

Represents a method that performs a function using the supplied arguments.

**Parameters:**

| Parameter   | Description                          |
|-------------|--------------------------------------|
| <i>argA</i> | The first argument to the function.  |
| <i>argB</i> | The second argument to the function. |

**Inherits From:** `System.Delegate`**Library:** BCL**Description**

A generic delegate type for two-argument methods, which perform a function (return a value).

**7.4 System.Function<A, B, C, D> delegate**

```

[ILAsm]
.class public auto ansi sealed System.Function`4<A, B, C, D>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance !3 Invoke(!0 argA,
                           !1 argB,
                           !2 argC)
}

[C#]
public delegate D Function<A, B, C, D>
    (A argA,
     B argB,
     C argC
    );

```

**Assembly Info:**

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - `CLSCompliantAttribute(true)`

**Implements:**

- System.ICloneable

**Summary:**

Represents a method that performs a function using the supplied arguments.

**Parameters:**

| Parameter   | Description                          |
|-------------|--------------------------------------|
| <i>argA</i> | The first argument to the function.  |
| <i>argB</i> | The second argument to the function. |
| <i>argC</i> | The third argument to the function.  |

**Inherits From:** System.Delegate

**Library:** BCL

**Description**

A generic delegate type for three-argument methods, which perform a function (return a value).

**7.5 System.Function<A, B, C, D, E> delegate**

```
[ILAsm]
.class public auto ansi sealed System.Function`5<A, B, C, D, E>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance !4 Invoke(!0 argA,
                           !1 argB,
                           !2 argC,
                           !3 argD)
}

[C#]
public delegate E Function<A, B, C, D, E>
    (A argA,
     B argB,
     C argC,
     D argD
    );
```

**Assembly Info:**

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - CLSCompliantAttribute(true)

**Implements:**

- `System.ICloneable`

**Summary:**

Represents a method that performs a function using the supplied arguments.

**Parameters:**

| Parameter   | Description                          |
|-------------|--------------------------------------|
| <i>argA</i> | The first argument to the function.  |
| <i>argB</i> | The second argument to the function. |
| <i>argC</i> | The third argument to the function.  |
| <i>argD</i> | The fourth argument to the function. |

**Inherits From:** `System.Delegate`

**Library:** BCL

**Description**

A generic delegate type for four-argument methods, which perform a function (return a value).

## 7.6 System.Function<A, B, C, D, E, F> delegate

```
[ILAsm]
.class public auto ansi sealed System.Function`6<A, B, C, D, E, F>
    extends System.Delegate
{
    .method public hidebysig newslot virtual
        instance !5 Invoke(!0 argA,
                            !1 argB,
                            !2 argC,
                            !3 argD,
                            !4 argE)
}

[C#]
public delegate F Function<A, B, C, D, E, F>
    (A argA,
     B argB,
     C argC,
     D argD,
     E argE
    );
```

### Assembly Info:

- *Name:*
- *Public Key:*
- *Version:*
- *Attributes:*
  - CLSCompliantAttribute(true)

### Implements:

- System.ICloneable

### Summary:

Represents a method that performs a function using the supplied arguments.

**Parameters:**

| Parameter   | Description                          |
|-------------|--------------------------------------|
| <i>argA</i> | The first argument to the function.  |
| <i>argB</i> | The second argument to the function. |
| <i>argC</i> | The third argument to the function.  |
| <i>argD</i> | The fourth argument to the function. |
| <i>argE</i> | The fifth argument to the function.  |

**Inherits From:** `System.Delegate`**Library:** BCL**Description**

A generic delegate type for five-argument methods, which perform a function (return a value).

**8 System.Optional<T> structure**

```

[ILAsm]
.class public sequential serializable sealed
    Optional`1<T>
    extends System.ValueType
    implements System.IComparable,
        System.IComparable`1<valuetype Optional`1<!0>>,
        System.IEquatable`1<valuetype Optional`1<!0>>,
        System.INullableValue

[C#]
public struct Optional<T> : IComparable,
    IComparable<Optional<T>>,
    IEquatable<Optional<T>>,
    INullableValue

```

**Assembly Info:**

- *Name:*
- *Public Key:*
- *Version:*

- *Attributes:*
  - `CLSCompliantAttribute(true)`

### Implements:

- `System.IComparable`
- `System.IComparable<System.Optional<T>>`
- `System.IEquatable<System.Optional<T>>`
- `System.INullableValue`

### Summary

Represents an optional value. Similar to `System.Nullable<T>` except that the generic type parameter is not constrained in any way.

**Inherits From:** `System.ValueType`

**Library:**

**Thread Safety:** This type is not guaranteed to be safe for multithreaded operations.

### Description

The `System.Optional<T>` value type represents a value of a given type `T` or the lack of such a value. For example an instance of `System.Optional<System.Int32>` contains a `System.Int32` value or an indication that no value is available. Instances of this type are immutable.

An instance of `System.Optional<T>` has two properties, `HasValue` and `Value`. Property `HasValue` is used to determine whether the current instance has a value of type `T`. It returns `true` or `false`, and never throws an exception. Property `Value` returns the value of the instance, provided it has one (i.e., `HasValue` is `true`); otherwise, it throws an exception.

In addition to the above properties, there is a pair of methods, both overloads of `GetValueOrDefault`. The version taking no arguments returns the instance's value of type `T`, if it has one; otherwise, it returns the default value of type `T`. The version taking a value argument of type `T` returns the instance's value of type `T`, if it has one; otherwise, it returns the value argument passed to it.

Applying `System.Optional<T>.HasValue` to an instance that has the default initial value returns `false`.

`System.Optional<T>` is similar to `System.Nullable<T>` but is not constrained to containing non-nullable value types. Conversion methods, `System.Optional<T>.FromNullable` and `System.Optional<T>.ToNullable`, are provided between the types.

See also `System.Either<A, B>` that represents either a value of type A or a value of type B.

## 8.1 `Optional<T>(T)` constructor

```
[ILAsm]
public rtspecialname specialname instance void .ctor(!0 value)

[C#]
public Optional(T value)
```

### Summary

Constructs and initializes a new instance of `System.Optional<T>` containing the specified value.

### Parameters

| Parameter    | Description                     |
|--------------|---------------------------------|
| <i>value</i> | The value for the new instance. |

### Description

Constructs a new instance of `System.Optional<T>` containing the supplied value of type T. Once this constructor has executed, calling `System.Optional<T>.HasValue` to the new instance returns `true` and `System.Optional<T>.Value` returns the value.

## 8.2 `Optional<T>.CompareTo(System.Object)` method

```
[ILAsm]
.method private final hidebysig virtual
    int32 CompareTo(object other)

[C#]
int CompareTo(object other)
```

### Summary

Returns the sort order of the current instance compared to the specified `System.Object`.

**Parameters**

| Parameter    | Description                                                        |
|--------------|--------------------------------------------------------------------|
| <i>other</i> | The <code>System.Object</code> to compare to the current instance. |

**Return Value**

The return value is a negative number, zero, or a positive number reflecting the sort order of the current instance as compared to *other*. For non-zero values, the exact value returned by this method is unspecified. The following table defines the conditions under which the return value is a negative number, zero, or a positive number.

| Return Value        | Description                                                            |
|---------------------|------------------------------------------------------------------------|
| Any negative number | Current instance < <i>other</i> .                                      |
| Zero                | Current instance == <i>other</i> .                                     |
| Any positive number | Current instance > <i>other</i> , or <i>other</i> is a null reference. |

If *other* is null, the returned value is 0 if `System.Optional<T>.HasValue` is false, or 1 otherwise. If *other* is non-null but not an instance of `System.Optional<T>`, an exception is thrown. Otherwise, the result is computed from the `System.Optional<T>.HasValue` and `System.Optional<T>.Value` properties, as follows:

| Return Value                                     | Conditions |                                      |
|--------------------------------------------------|------------|--------------------------------------|
|                                                  | HasValue   | <i>other</i> .HasValue               |
| 0                                                | false      | false <b>or</b> <i>other</i> is null |
| Some negative number                             | false      | true                                 |
| Some positive number                             | true       | false <b>or</b> <i>other</i> is null |
| <code>Value.CompareTo(<i>other</i>.Value)</code> | true       | true                                 |

**Description**

[Note: This method is implemented to support the `System.IComparable` interface.]

## Exceptions

| Exception                | Condition                                                                                                                                                         |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| System.ArgumentException | <i>other</i> is not null and not an instance of <code>Optional&lt;T&gt;</code> .<br>or<br>Type <code>T</code> doesn't implement <code>System.IComparable</code> . |

8.3 `Optional<T>.CompareTo(Optional<T>)` method

```

[ILAsm]
.method public hidebysig virtual final
    int32 CompareTo(valuetype Optional`1<!0> other)

[C#]
public int CompareTo(Optional<T> other)

```

## Summary

Returns the sort order of the current instance compared to the specified object.

## Parameters

| Parameter    | Description                                                                   |
|--------------|-------------------------------------------------------------------------------|
| <i>other</i> | The <code>System.Optional&lt;T&gt;</code> to compare to the current instance. |

## Return Value

A value that reflects the sort order of the current instance as compared to *other*. For non-zero values, the exact value returned by this method is unspecified. The following table defines the conditions under which the returned value is a negative number, zero, or a positive number.

| Returned Value   | Description                                   |
|------------------|-----------------------------------------------|
| A negative value | The current instance is < <i>other</i> .      |
| Zero             | The current instance is == <i>other</i> .     |
| A positive value | The current instance is > than <i>other</i> . |

If either of the current instance or *other* is not an instance of `System.Optional<T>`, an exception is thrown. Otherwise, the result is computed from the `System.Optional<T>.HasValue` and `System.Optional<T>.Value` properties, as follows:

| Return Value                              | Conditions |                |
|-------------------------------------------|------------|----------------|
|                                           | HasValue   | other.HasValue |
| 0                                         | false      | false          |
| Some negative number                      | false      | true           |
| Some positive number                      | true       | false          |
| <code>Value.CompareTo(other.Value)</code> | true       | true           |

### Description

If `T` implements `System.IComparable<T>`, that interface's method is used. Otherwise, if `T` implements `System.IComparable`, that interface's method is used. Otherwise, an exception is thrown.

[Note: This method implicitly implements the `System.IComparable<Optional<T>>.CompareTo` method.]

### Exceptions

| Exception                             | Condition                                                                                                           |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <code>System.ArgumentException</code> | Type <code>T</code> doesn't implement <code>System.IComparable&lt;T&gt;</code> or <code>System.IComparable</code> . |

## 8.4 Optional<T>.Equals(System.Object) method

```
[ILAsm]
.method public hidebysig virtual bool Equals(object other)
```

```
[C#]
public override bool Equals(object other)
```

### Summary

Determines whether the current instance and the specified `System.Object` represent the same type and value.

### Parameters

| Parameter    | Description                                                        |
|--------------|--------------------------------------------------------------------|
| <i>other</i> | The <code>System.Object</code> to compare to the current instance. |

## Return Value

The following table defines the conditions under which the return value is `true` or `false`:

| Return Value                           | Conditions                                                  |                                      |
|----------------------------------------|-------------------------------------------------------------|--------------------------------------|
|                                        | HasValue                                                    | other.HasValue                       |
| false                                  | The current instance and <i>other</i> have different types. |                                      |
| true                                   | false                                                       | false <b>or</b> <i>other</i> is null |
| false                                  | false                                                       | true                                 |
| false                                  | true                                                        | false <b>or</b> <i>other</i> is null |
| <code>Value.Equals(other.Value)</code> | true                                                        | true                                 |

## Description

[*Note:* This method overrides `System.Object.Equals.`]

## 8.5 Optional<T>.Equals(Optional<T>) method

```
[ILAsm]
.method public hidebysig virtual final
    bool Equals(valuetype Optional`1<!0> other)

[C#]
public bool Equals(Optional<T> other)
```

## Summary

Determines whether the specified object is equal to the current object.

## Parameters

| Parameter    | Description                                                            |
|--------------|------------------------------------------------------------------------|
| <i>other</i> | The <code>Optional&lt;T&gt;</code> to compare to the current instance. |

## Return Value

The following table defines the conditions under which the return value is `true` or `false`:

| Return Value                           | Conditions         |                    |
|----------------------------------------|--------------------|--------------------|
|                                        | HasValue           | other.HasValue     |
| <code>true</code>                      | <code>false</code> | <code>false</code> |
| <code>false</code>                     | <code>false</code> | <code>true</code>  |
| <code>false</code>                     | <code>true</code>  | <code>false</code> |
| <code>Value.Equals(other.Value)</code> | <code>true</code>  | <code>true</code>  |

## Description

[*Note:* This method implicitly implements the `System.IEquatable<Optional<T>>.Equals` method.]

## 8.6 Optional<T>.FromNullable<U>(Nullable<U>) method

```
[ILAsm]
.method public hidebysig static valuetype Optional`1<!!0>
    FromNullable<valuetype U>
        (valuetype Nullable`1<!!0> value)

[C#]
public static Optional<U> FromNullable(Nullable<U> value)
    where U : struct
```

## Summary

Perform a conversion of a `System.Nullable<U>` value to `System.Optional<U>`.

## Parameters

| Parameter    | Description                                                                                           |
|--------------|-------------------------------------------------------------------------------------------------------|
| <i>value</i> | The <code>System.Nullable&lt;U&gt;</code> value to convert to <code>System.Optional&lt;U&gt;</code> . |

## Return Value

A `System.Optional<U>` with the specified value.

## Description

Perform a conversion of a `System.Nullable<U>` value to `System.Optional<U>`. The type `U` is constrained to be a value type to satisfy the requirements of `System.Nullable<U>`.

## 8.7 `Optional<T>.FromOptional(System.Optional<T>)` method

```
[ILAsm]
.method public hidebysig static !0 FromOptional(valuetype
System.Optional`1<!0> value)
```

```
[C#]
public static explicit operator T(Optional<T> value)
```

## Summary

Perform a conversion of a `System.Optional<T>` value to type `T`.

## Parameters

| Parameter    | Description                                                                         |
|--------------|-------------------------------------------------------------------------------------|
| <i>value</i> | The <code>System.Optional&lt;T&gt;</code> value to convert to type <code>T</code> . |

## Return Value

The value, if any, of the specified optional value. Otherwise, an exception is thrown.

## Description

[Note: This method is provided for CLS compliance and is equivalent to `System.Optional<T>.op_explicit(T)`.]

[Note: The conversion implemented by this method corresponds exactly to obtaining the value of the `System.Optional<T>.Value` property.]

## Exceptions

| Exception                                     | Condition                                                |
|-----------------------------------------------|----------------------------------------------------------|
| <code>System.InvalidOperationException</code> | <code>System.Optional&lt;T&gt;.HasValue</code> is false. |

## 8.8 Optional<T>.GetHashCode() method

```
[ILAsm]
.method public hidebysig virtual int32 GetHashCode()

[C#]
public override int GetHashCode()
```

### Summary

Generates a hash code for the value of the current instance.

### Return Value

If `System.Optional<T>.HasValue` is true, a `System.Int32` containing the hash code for the value of the current instance is returned; otherwise, 0 is returned.

### Description

The algorithm used to generate the hash code when `System.Optional<T>.HasValue` is true is unspecified.

[*Note:* This method overrides `System.Object.GetHashCode`.]

## 8.9 Optional<T>.GetValueOrDefault() method

```
[ILAsm]
.method public hidebysig !0 GetValueOrDefault()

[C#]
public T GetValueOrDefault()
```

### Summary

Returns the value of the current instance, or if it has none, returns the default value for the type T.

### Return Value

A value of type T, which is either the value of the current instance, or if it has none, the default value for the type T.

### Description

[*Note:* Another method, `System.Optional<T>.GetValueOrDefault(T)`, allows a value other than the default value of type T to be returned if the current instance has no value.]

8.10 Optional<T>.GetValueOrDefault(T) method

```
[ILAsm]
.method public hidebysig !0 GetValueOrDefault(!0 alternateDefaultValue)

[C#]
public T GetValueOrDefault(T alternateDefaultValue)
```

Summary

Returns the value of the current instance, or if it has none, returns *alternateDefaultValue*.

Parameters

| Parameter                    | Description                                                    |
|------------------------------|----------------------------------------------------------------|
| <i>alternateDefaultValue</i> | The value to be returned if the current instance has no value. |

Return Value

A value of type T, which is either the value of the current instance, or if it has none, the value *alternateDefaultValue*.

Description

[Note: `System.Optional<T>.GetValueOrDefault()` allows the default value for type T to be returned if the current instance has no value.]

8.11 Optional<T>.HasValue property

```
[ILAsm]
.property bool HasValue()
{
    .get instance bool get_HasValue()
}
.method public hidebysig specialname instance bool get_HasValue()

[C#]
public bool HasValue { get; }
```

Summary

Indicates whether the current instance contains a value.

## Property Value

true if the current instance contains a value; otherwise, false.

## Behaviors

If `System.Optional<T>.HasValue` is true, the instance contains a value of type T, and `System.Optional<T>.Value` returns that value. If `System.Optional<T>.HasValue` is false, the instance contains no value of type T, and an attempt to read `System.Optional<T>.Value` results in a `System.InvalidOperationException` exception. A call to `System.Optional<T>.Value.GetValueOrDefault` returns the default value.

This property is read-only.

[Note: This method implicitly implements the `Optional<T>.INullableValue.HasValue` property.]

## 8.12 `Optional<T>.op_Equality(Optional<T>, Optional<T>)` method

```
[ILAsm]
.method public hidebysig specialname static
    bool op_Equality(valuetype Optional`1<!0> left,
                    valuetype Optional`1<!0> right)

[C#]
static bool operator==(Optional<T> left, Optional<T> right)
```

## Summary

Determines whether the specified values are equal.

## Parameters

| Parameter    | Description                                                 |
|--------------|-------------------------------------------------------------|
| <i>left</i>  | The first <code>Optional&lt;T&gt;</code> value to compare.  |
| <i>right</i> | The second <code>Optional&lt;T&gt;</code> value to compare. |

## Return Value

The following table defines the conditions under which the return value is `true` or `false`:

| Return Value                                | Conditions         |                    |
|---------------------------------------------|--------------------|--------------------|
|                                             | left.HasValue      | right.HasValue     |
| <code>true</code>                           | <code>false</code> | <code>false</code> |
| <code>false</code>                          | <code>false</code> | <code>true</code>  |
| <code>false</code>                          | <code>true</code>  | <code>false</code> |
| <code>left.Value.Equals(right.Value)</code> | <code>true</code>  | <code>true</code>  |

## Description

### 8.13 Optional<T>.op\_Explicit(System.Optional<T>) method

```
[ILAsm]
.method public hidebysig static specialname !0 op_Explicit(valuetype
Optional`1<!0> value)

[C#]
public static explicit operator T(Optional<T> value)
```

## Summary

Perform an explicit conversion of a `System.Optional<T>` value to type `T`.

## Parameters

| Parameter          | Description                                                                         |
|--------------------|-------------------------------------------------------------------------------------|
| <code>value</code> | The <code>System.Optional&lt;T&gt;</code> value to convert to type <code>T</code> . |

## Return Value

The value, if any, of the specified optional value. Otherwise, an exception is thrown.

## Description

[Note: See the `System.Optional<T>.FromOptional(Optional<T>)` method for the CLS twin of this operator.]

[Note: The conversion implemented by this method corresponds exactly to obtaining the value of the `System.Optional<T>.Value` property.]

**Exceptions**

| Exception                                     | Condition                                                |
|-----------------------------------------------|----------------------------------------------------------|
| <code>System.InvalidOperationException</code> | <code>System.Optional&lt;T&gt;.HasValue</code> is false. |

**8.14 Optional<T>.op\_Implicit(T) method**

```
[ILAsm]
.method public hidebysig static specialname valuetype Optional`1<!0>
op_Implicit(!0 value)
```

```
[C#]
public static implicit operator Optional<T>(T value)
```

**Summary**

Perform an implicit conversion of a `T` value to `System.Optional<T>`.

**Parameters**

| Parameter    | Description                                                                    |
|--------------|--------------------------------------------------------------------------------|
| <i>value</i> | The <code>T</code> value to convert to <code>System.Optional&lt;T&gt;</code> . |

**Return Value**

A `System.Optional<T>` with the specified value.

**Description**

[*Note:* See the `System.Optional<T>.ToOptional(T)` method for the CLS twin of this operator.]

[*Note:* The conversion implemented by this method corresponds exactly to invoking the `System.Optional<T>(T)` constructor.]

## 8.15 Optional&lt;T&gt;.op\_Inequality(Optional&lt;T&gt;, Optional&lt;T&gt;) method

```

[ILAsm]
.method public hidebysig specialname static
    bool op_Inequality(valuetype Optional`1<!0> left,
                      valuetype Optional`1<!0> right)

[C#]
static bool operator!=(Optional<T> left, Optional<T> right)

```

## Summary

Determines whether the specified values are not equal.

## Parameters

| Parameter    | Description                              |
|--------------|------------------------------------------|
| <i>left</i>  | The first Optional<T> value to compare.  |
| <i>right</i> | The second Optional<T> value to compare. |

## Return Value

The following table defines the conditions under which the return value is true or false:

| Return Value                       | Conditions    |                |
|------------------------------------|---------------|----------------|
|                                    | left.HasValue | right.HasValue |
| false                              | false         | false          |
| true                               | false         | true           |
| true                               | true          | false          |
| Not left.Value.Equals(right.Value) | true          | true           |

## Description