



**Methods for Testing and Specification (MTS);
The Testing and Test Control Notation version 3;
TTCN-3 Language Extensions: Object-Oriented Features**

Reference

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Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Methods for Testing and Specification (MTS), and is now submitted for the ETSI standards Membership Approval Procedure.

The use of underline (additional text) and strike through (deleted text) highlights the differences between base document and extended documents.

The present document relates to the multi-part standard ETSI ES 201 873 covering the Testing and Test Control Notation version 3, as identified in ETSI ES 201 873-1 [1].

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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1 Scope

The present document defines the support for object-oriented features in TTCN-3. TTCN-3 can be used for the specification of all types of reactive system tests over a variety of communication ports. Typical areas of application are protocol testing (including mobile and Internet protocols), service testing (including supplementary services), module testing, testing of OMG CORBA based platforms, APIs, etc. TTCN-3 is not restricted to conformance testing and can be used for many other kinds of testing including interoperability, robustness, regression, system and integration testing. The specification of test suites for physical layer protocols is outside the scope of the present document.

TTCN-3 packages are intended to define additional TTCN-3 concepts, which are not mandatory as concepts in the TTCN-3 core language, but which are optional as part of a package which is suited for dedicated applications and/or usages of TTCN-3.

While the design of TTCN-3 package has taken into account the consistency of a combined usage of the core language with a number of packages, the concrete usages of and guidelines for this package in combination with other packages is outside the scope of the present document.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <https://docbox.etsi.org/Reference/>.

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The following referenced documents are necessary for the application of the present document.

- [1] ETSI ES 201 873-1: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 1: TTCN-3 Core Language".
- [2] ETSI ES 201 873-4: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 4: TTCN-3 Operational Semantics".
- [3] ETSI ES 201 873-5: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 5: TTCN-3 Runtime Interface (TRI)".
- [4] ETSI ES 201 873-6: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 6: TTCN-3 Control Interface (TCI)".

2.2 Informative references

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] ETSI ES 201 873-7: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 7: Using ASN.1 with TTCN-3".

- [i.2] ETSI ES 201 873-8: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 8: The IDL to TTCN-3 Mapping".
- [i.3] ETSI ES 201 873-9: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 9: Using XML schema with TTCN-3".
- [i.4] ETSI ES 201 873-10: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 10: TTCN-3 Documentation Comment Specification".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI ES 201 873-1 [1], ETSI ES 201 873-4 [2], ETSI ES 201 873-5 [3] and ETSI ES 201 873-6 [4] apply.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI ES 201 873-1 [1], ETSI ES 201 873-4 [2], ETSI ES 201 873-5 [3] and ETSI ES 201 873-6 [4] apply.

4 Package conformance and compatibility

The package presented in the present document is identified by the package tag:

`"TTCN-3:2018 Object-Oriented features"` - to be used with modules complying with the present document.

For an implementation claiming to conform to this package version, all features specified in the present document shall be implemented consistently with the requirements given in the present document and in ETSI ES 201 873-1 [1] and ETSI ES 201 873-4 [2].

The package presented in the present document is compatible to:

- ETSI ES 201 873-1 [1], version 4.10.1;
- ETSI ES 201 873-4 [2], version 4.6.1;
- ETSI ES 201 873-5 [3], version 4.8.1;
- ETSI ES 201 873-6 [4], version 4.9.1;
- ETSI ES 201 873-7 [i.1];
- ETSI ES 201 873-8 [i.2];
- ETSI ES 201 873-9 [i.3];
- ETSI ES 201 873-10 [i.4].

If later versions of those parts are available and should be used instead, the compatibility to the package presented in the present document has to be checked individually.

5 Package Concepts for the Core Language

5.0 General

This package defines objec-oriented features for TTCN-3, i.e. it extends the TTCN-3 core language (ETSI ES 201 873-1 [1]) with well-known concepts from object-oriented programming and modelling languages. This package realizes the following concepts:

- classes (i.e. class definition, scope rules, abstract and external classes, refinement, constructors, destructors, methods, visibility, and built-in classes);
- objects (i.e. ownership, object references, select class-statement, dynamic class discrimination and casting); and
- exception handling (i.e. ability to define exception handling for functions, external functions, altsteps and test cases).

5.1 Classes and Objects

5.1.0 General

This clause introduces the concepts of class types and their values, called objects as well as the operations allowed to be applied to these objects.

5.1.1 Classes

5.1.1.0 General

Syntactical Structure

```
[public | private]
type [external] class [@final |@abstract]
Identifier [extends ClassType]
[runsOnSpec] [systemSpec] [mtcSpec]
"{" {ClassMember} }"
[finally StatementBlock]
```

Semantic Description

A class is a type where the values are called objects. A class can declare fields (variables, constants, templates, timers, classes) and methods as its members. Each member name inside the class shall be unique, there is no overloading. The private and protected fields and methods are only accessible by the methods of the class, while the public members of the class can be accessed also from behaviour not defined in the class. The private members of the class can be accessed directly only by members of the class itself. All members which are neither private nor public are protected and can also be accessed by members of subclasses.

All fields may be declared without initializer, even const and template fields.

A class can extend another class. The extended class is called the superclass, while the extending class is called the subclass. The resulting type of a class definition is the set of object instances of the class itself and all instances of its direct or indirect subclasses. A subclass is a subtype of its direct and indirect superclasses and its object instances are type compatible with them. If a class does not explicitly extend another class type, it implicitly extends the root class type **object**. Thus, all classes are directly or indirectly extensions of the **object** class.

A class can have optional runs on, mtc and system clauses. This restricts the type of component context that can create objects of that class and all methods of this class. If a class does not have one of these clauses, it inherits it from its superclass, if the superclass has one. If the superclass has or inherits a runs on, mtc or system clause, the subclass may declare each of these clauses with a more specific component type than the one inherited. The function members of classes shall not have runs on, system or mtc classes but inherit them from their surrounding class or its superclasses.

Restrictions

- a) Templates are not allowed for class types.
- b) Passing of object references to the create operation of a component type or a function started on another component is not allowed.
- c) No subtyping definition is allowed for class types via the normal subtype definition.
- d) No local/global constants or module parameters of class type or containing class type fields or elements are allowed.
- e) Class type cannot be the contained value of an anytype value.
- f) The functions of a class shall not have a runs on, mtc or system clause.
- g) The runs on type of a class shall be runs on compatible with the runs on type of the behaviour creating a class.
- h) The runs on type of a class shall be runs on compatible with the runs on type of the superclass.
- i) The mtc and system type of a class shall be mtc and system compatible with the mtc and system types of the superclass, respectively.

5.1.1.1 Scope rules

Class constitutes a scope unit. For the uniqueness of identifiers, the rules specified in clause 5.2.2 of ETSI ES 201 873-1 [1] apply with the following exceptions:

- a) Identifiers from the higher scope can be reused for member declarations. A reference to a reused identifier without a prefix occurring inside a class scope shall be resolved as a reference to the class member. In order to refer to the declaration on the higher scope, the identifier shall be preceded with a module name and a dot (".").
- b) Identifiers of member declarations can be reused inside methods for formal parameter and local declarations. A reference to a reused identifier without a prefix occurring inside a class method shall be resolved as a reference to the formal parameter or local declaration. In order to refer to the member declaration, the identifier shall be preceded with the `this` keyword and a dot.
- c) Reusing identifiers of members of the component type specified in the runs on clause of the class for members and inside methods for formal parameters and local declarations is not allowed.

EXAMPLE:

```

module ClassModule {
  const integer a := 1;

  type class MyClass() {
    const integer a := 2;
    function doSomething (integer a := 3) {
      log(a); // logs 3 (for the default value)
      log(this.a); // logs 2
      log(ClassModule.a); // logs 1
    }
    function doSomethingElse () {
      log(a); // logs 2
      log(this.a); // also logs 2
      log(ClassModule.a); // logs 1
    }
  }
}

```

5.1.1.2 Abstract classes

A class can be declared as `@abstract`. In that case, it is allowed that it also declares abstract member functions who shall be defined by all non-abstract subclasses. An abstract method function has no function body but can be called in all concrete instances of subclasses of the abstract class declaring it. Other members of the abstract class or its subclasses may use the abstract functions as if it was concrete where at runtime the concrete overriding definition will be used.

NOTE 1: Abstract classes are only useful as superclasses of concrete classes.

Restrictions

- a) Abstract classes cannot be explicitly instantiated.
- b) If a class that is not declared abstract extends an abstract class, all methods that have no implementation in the superclass shall be implemented in this class.

NOTE 2: Variables of an abstract class type can only contain references to instances of non-abstract subclasses.

5.1.1.3 External classes

A class may also be declared as external. In that case, it may declare external member functions without a function body. It is allowed to omit the external keyword from these function declarations. External classes can extend non-external classes but classes not declared as external shall not extend from external classes. External classes may also define other members like normal classes. When instantiating an external class, the external object being created is provided by the platform adapter and the external method calls to the external object are delegated via the platform adapter to the corresponding method of the external object.

NOTE 1: External classes are a way to use object-oriented library functionality in TTCN-3 while still remaining abstract and independent of actual implementation. Libraries for common constructs like stacks, collections, tables can be defined or automatic import mechanisms could be provided.

If an object of an external class is instantiated, it implicitly creates an external object and the internal object has a handle to the external one. The reference to the external object is called a handle. When an external method is invoked on the internal object, the call is delegated to the handle.

NOTE 2: External objects are possibly shared between different parts of the test system. Therefore, racing conditions and deadlocks have to be avoided by the external implementation.

Restrictions

- a) Void
- b) Void
- c) Void
- d) An internal class shall not extend an external class

EXAMPLE:

```
type class @abstract Collection {
  function @abstract size() return integer;
  // internal default implementation
  function isEmpty() return boolean {
    return size() == 0
  }
}

type external class Stack extends Collection {
  function push(integer v);
  function pop() return integer;
  function isEmpty() return boolean; // external implementation overrides internal
  function size() return integer; // external implementation of abstract function}

```

5.1.1.4 Final Classes

If a class shall not be subclassed, it may be declared as `@final`. Final classes cannot be abstract.

5.1.1.5 Constructors**Syntactic Structure**

```
create "(" { FormalParameter , }* ")"
[ external "(" { FormalParameter , }* ")" ]
[":" ClassType "(" { ActualParameter , }+ ")" ]
[ StatementBlock ]

```

Semantic Description

A class may define a constructor called `create`.

If no constructor is defined inside a class body, an implicit default constructor is provided where the formal parameters of the constructor are the parameters of the (implicit or explicit) constructor of the direct superclass and one additional formal in parameter for each declared `var` field of the class itself and also all `const` or `template` fields with no initializer in their order of declaration with the same type as in the declaration.

The constructor is invoked on a type reference to the class and the result of this invocation is a new instance object of the constructor's specific class. If a class is extending another class with a constructor with at least one parameter without default, that constructor shall be invoked by adding a super-constructor clause to the constructor declaration. The super-constructor clause consist of a reference to the class being extended and an actual parameter list. An implicit constructor will automatically pass the required actual parameters to the constructor of its superclass.

In the constructor, it is allowed to refer to the object being constructed as `this` to reference the fields of the object to be created in case that the names of the formal parameters clash with the names of those fields. They are explicitly allowed to have the same names as class members.

When an object is created via the invocation of a constructor, the fields of each class body in the class hierarchy that have initializers are initialized before the execution of that class body's constructor body. The fields of a superclass that have initializers are initialized before the fields of the subclass. Also, the constructor of the superclass is executed before the constructor body of the subclass. Thus, it is ensured that all initialization of the superclass hierarchy as well as local fields with initializers is finished before the execution of a constructor body.

Since the members of a class body can appear in any order and forward references are allowed between them, a field with an initializer which is referenced by the initializer of another field, is initialized first.

As the underlying external constructor of external classes might need additional parameters, these can be provided via the additional external formal parameter list. If no internal constructor needs to be defined, the constructor may be defined without external formal parameter list and no body. In that case, the formal parameter list defines the formal parameters passed to the external constructor.

Restrictions

- a) All formal parameters of the constructor shall be `in` parameters.
- b) The constructor body shall not assign anything to variables that are not local to the constructor body or accessible fields of the class the constructor belongs to.
- c) The constructor body shall not use blocking operations.
- d) The initialization of a member field shall not invoke any member function in the object being initialized.
- e) The constructor body shall not invoke any member function in the object being initialized.
- f) A member constant or template shall be initialized exactly once, either by its initialization part or by at most one constructor body.
- g) Direct or indirect cyclic initialization is not allowed. That is the initializer of a field shall not use the same field directly or indirectly.
- h) The initializer of a field shall not use a field that does not have an initializer.

EXAMPLE 1:

```
type class MyClass {
  var integer a;
  const float b;
  const float c := 7;
  template float myTemplate := ?;
  // implicit constructor:
  // only using variable fields and non-variable fields with no initializer
  //create(integer a, float b) { // no parameter for c and myTemplate
  //  this.a := a;
  //  this.b := b
  //}
}
```

```

type class MyClass2 extends MyClass {
  template integer t;
  // explicit constructor
  create(template integer t) : MyClass(2, 0.5) {
    this.t := t;
  }
}

type class MyClass3 extends MyClass {
  var float f;
  // implicit constructor:
  // create(integer a, float b, float f) : MyClass(a, b) {
  //   this.f := f;
  // }
}

```

EXAMPLE 2:

For each initialization statement it is marked with its initialization order in the comment.

```

type class MySuperClass {
  var integer a := 5; // 1
  const float b;
  create(integer a, float b) {
    this.a := a; // 3
    this.b := b; // 4
  }
}

type class MySubClass extends MySuperClass {
  var template integer t := ?; // 2
  create(template integer t) : MySuperClass(2, 0.5) {
    this.t := t; // 5
  }
}

```

5.1.1.6 Constructor invocation

Syntactic Structure

ClassReference "." **create** [*ActualParList*] [**external** *ActualParList*]

Semantic Description

To instantiate an object, the constructor of the class is invoked. The result of that operation is a reference to a newly constructed object of the given concrete class.

If the constructor is a constructor of an external class that has an external formal parameter list, an additional external actual parameter list is given following the external keyword. If the constructor is to be invoked with a parameter list with no actual parameters, then the whole actual parameter list may be omitted.

If the constructor of an external class is invoked, first the external object is created using the given external formal parameters, then the internal constructor is evaluated to initialize the internal part of the object.

EXAMPLE:

```

type class Named {
  var charstring name;
}

type external class Address extends Named {
  create(charstring name)
  external (charstring host, int portNr)
  : Named(name){}
}

type external class UnnamedAddress {
  create (charstring host, int portNr);
}

var Address v_addr := Address.create("Connection 1") external ("127.0.0.1", 555);
var UnnamedAddress := UnnamedAddress.create("127.0.0.1", 555);
var Stack v_stack := Stack.create; // only implicit external constructor without parameters

```

5.1.1.7 Destructors

Syntactic Structure

```
finally StatementBlock
```

Semantic Description

A destructor may be provided using a finally declaration following the class body. This destructor will be invoked automatically at the latest before the system deallocates an object instance (which is tool specific and out of the scope of the present document) or when the owning component is terminates. The *StatementBlock* has access to all members accessible to the class. The *StatementBlock* is semantically a function body of a function without return clause.

When deallocating the object instance, the destructor of the associated class is invoked first, followed by the destructor of all parent classes in the reverse order of superclass hierarchy.

5.1.1.8 Methods

A method is a function defined inside the class body. It has the same properties and restrictions as any normal function, but it is invoked in an object which can be referred to by the `this` object reference. A method invocation can access the class's own fields and also the inherited protected fields and methods of its superclasses.

A method inherited from a superclass can be overridden by the subclass by redefining a function of the same name and with the same formal parameter list. When a method is called in an object, the version of the most specific class of the super class hierarchy of the concrete class that defines the method in its body will be invoked. The overridden method can be invoked from the overriding class by using the keyword `super` as the object reference of the invocation. If a method shall not be overridden by any subclass, it can be declared as `@final`.

Public methods, if not overridden by the subclass, are inherited from the superclasses. If a public method is declared in a class, it can be invoked also in all objects of its direct or indirect subclasses.

If a public method is overridden, the overriding method shall have the same formal parameters in the same order as the overridden method. Public methods shall be overridden only by public methods. Protected methods may be overridden by public or protected methods.

The return type of an overriding function shall be the same as the return type of the overridden function with the same template restrictions and modifiers.

Methods shall have no `runs on`, `system` or `mtc` clause directly attached to them. However, they inherit these clauses from their surrounding class.

5.1.1.9 Method invocation

Syntactical Structure

```
[ (ObjectInstance | "super") "." ] Identifier "(" FunctionActualParList ")"
```

A method invocation is a function call associated with a certain object defined in the class of that object.

Methods are invoked using the dotted notation on an object reference. Inside the scope of a class, methods of the same class or any visible inherited methods can be invoked without the *ObjectInstance* prefix if the object the method shall be invoked in is the same object as the one invoking it. The usual restrictions on actual parameters, as well as `runs on`, `mtc` and `system` types apply also on method invocations. All other restrictions that apply to called functions also apply to method invocation.

The `super` keyword shall only be used from inside a class member definition to access one of the accessible methods inherited from the super class of the member's containing class.

5.1.1.10 Visibility

Fields can be declared as private or protected. Methods can be declared as private, public or protected. If no visibility is given then the default modifier protected is assumed.

Private member functions are not visible and can be present in multiple classes of the same hierarchy with different parameter lists and return values.

Public member functions can be called from any behaviour running on the object's owner component.

Restrictions

- a) A field of any visibility cannot be overridden by a subclass.
- b) A public member function can only be overridden by another public member function.
- c) Private members can only be accessed directly from inside their surrounding class's scope.

5.1.1.11 Built-in classes

The abstract special built-in class called `object` is the superclass for all classes that do not explicitly extend another class.

The pseudo definition of that class is:

```
type class @abstract @builtin object {
    // This function will return a tool-specific descriptive string by default
    // but can be overridden by subclasses
    public function toString() return universal charstring;
}
```

NOTE: The `@builtin` is only added for illustrative purposes and not part of the TTCN-3 language.

5.1.1.12 Nested classes

A class type definition may occur also as a member of another class type definition body. Such a class is called a nested class while the surrounding class is called the containing class.

Members defined in the body of a nested class may access all named entities that are accessible in the scope of the containing class with the same restrictions.

If a nested class does not have a `runs on` clause it inherits the `runs on` type from its enclosing class.

If a nested class does not have a `system` clause it inherits the `system` type from its enclosing class.

If a nested class does not have an `mtc` clause it inherits the `mtc` type from its enclosing class.

The type of the nested class may be referenced with the dotted notation applied to a type reference of the enclosing class.

The constructor of a nested class may be invoked on a reference composed of an instance of the containing class followed by a dot and nested class identifier. Inside the scope of the containing class, the identifier of the nested class may be used without dotted notation for the use of calling its constructor.

Restrictions

- a) The members of a nested class shall not have the same name as one of the members of a (directly or indirectly) containing class.
- b) Referencing the name of a nested class in a null reference via dotted notation shall cause an error.

EXAMPLE:

```
type record of charstring Strings;

type class @abstract StringIterator {
    function @abstract hasNext() return boolean;
```

```

function @abstract next() return charstring;
}

type class StringList {
  var Strings v_strings;

  type class Iterator extends StringIterator {
    var integer v_pos := 0;

    public function hasNext() return boolean {
      return v_pos < lengthof(v_strings);
    }

    public function next() return charstring {
      v_pos := v_pos + 1;
      return v_strings[v_pos-1];
    }
  }

  function iterator() return Iterator {
    return Iterator.create();
  }
}

var StringList v_list := StringList.create();
var StringList.Iterator v_iterator := v_list.Iterator.create();
v_list := null;
v_iterator := v_list.Iterator.create(); // error

```

5.1.2 Objects

5.1.2.0 General

Objects are the instances of classes. Each instance comprises an instance of the data of the fields of the class (including all superclasses) and allows invocation of its public methods by other behaviour and protected or private methods by behaviour defined by the object's class itself.

5.1.2.1 Ownership

Each object is owned by the component on which it was created. The owning component of an object can be referenced via the `self` component reference. Methods of objects can only be invoked by behaviour that also runs on the owning component. An object is created on a component if its constructor was invoked by a behaviour running on that component.

5.1.2.2 Object References

Objects are always passed by reference (even though their formal parameters can still be in, inout or out, dependent on the usage of that parameter). A variable of a class type contains only a reference to the object instance and the object is not copied when used as an actual parameter or assigned to a variable, but only the reference to the object. Therefore, multiple variables can contain a reference to the same object simultaneously.

Restrictions

- a) Object References shall not be passed as actual parameter or part of an actual parameter to either the create operation of a component type or a function started on a component. If a structured type contains a field of a class type, this type is not seen as a data type and its values cannot be used for sending and receiving or as an argument to any expression other than the equality/inequality operator.

NOTE: Since objects cannot be shared by different component contexts and for each component at most one behaviour is running, no parallel conflicting access to any of the objects fields or methods is possible.

5.1.2.3 Null reference

An object variable that is not initialized with an object instance contains the special value `null`. An object variable or parameter may be compared with the special value `null` with the equality and inequality operators or can be assigned the special value `null` explicitly.

5.1.2.4 Select class-statement

Syntactical Structure

```
select class "(" Object ")"
"{ " { case "(" ClassReference ")" StatementBlock }+ [ElseCase] " }
```

Semantic Description

The class of an object can be discriminated for via the 'select class' statement that is similar to a select union statement insofar that it allows only superclasses and known subclasses of the object reference's class in the context. If more than one case contains a superclass of the actual class of the given object instance, the first of these cases will be chosen by the select class statement.

In case that the *Object* is not an instance of any of the *ClassReferences* in the different cases, the statement block in the *ElseCase*, if present, will be executed.

EXAMPLE:

```
type class A {}
type class B extends A {}
...
var A v_a := B.create();
select class (v_a) {
  case (B) { ... } // will be chosen
  case (A) { ... } // will not be chosen
}
```

Restrictions

- a) If a class from one case is a superclass of a class from another case, then the case of the subclass shall be precede the case of the superclass.

5.1.2.5 Of-operator (Dynamic Class Discrimination)

Syntactical Structure

```
Object of ClassReference
```

Semantic Description

To check whether an object is an instance is of a certain class, the `of` operator may be used.

It yields a Boolean value which is true if and only if the most specific class of the object referenced on the left-hand side is either equal to or a subclass derived from the class type reference on the right-hand side.

5.1.2.6 Casting

Syntactical Structure

```
ObjectReference "=>" ( ClassIdentifier | "(" ClassReference ")" )
```

Semantic Description

An object reference can be cast to another class of the object's known class's set of direct or indirect superclasses and direct or indirect subclasses. This operation yields an object reference to the same object but can be used as being of the type being cast to. If the referenced class to be cast to is an expression that is not a simple identifier, the expression shall be written in parenthesis.

Restrictions

- a) If the class the object is being cast to is not in the set of superclasses or the concrete class of the object, the cast operation shall result in an error.

5.2 Exception handling

5.2.0 General

This clause introduces exception handling into TTCN-3. It provides means to define exception handling for functions, external functions, altsteps and test cases.

5.2.1 Extension to ETSI ES 201 873-1, clause 16.1.0 (Functions)

Clause 16.1.0 General

The syntax of functions is extended with an optional **exception** clause.

Syntactical Structure

```
function [ @deterministic | @control ] FunctionIdentifier
"(" { ( FormalValuePar | FormalTemplatePar ) [ "," ] } ")"
[ runs on ComponentType ]
[ mtc ComponentType ]
[ system ComponentType ]
[ return [ template ] Type ]
[ exception "(" {Type [ "," ]}+ ")" ]
StatementBlock
```

Clause 16.1.0 General

The semantic description part is extended.

Functions may have an exception list. The exception list declares, what exception types may be raised during the execution of the function either directly or indirectly.

NOTE 1: The exception list can be used to communicate to the callers of the function what exceptions to prepare for and by tools to perform stronger static checks. For backward compatibility reasons the exception list is optional.

NOTE 2: The exception list might not be exhaustive. With activated altsteps it might not be possible to precisely know what exceptions might be raised within a function directly or indirectly.

If the statement block of a function has a **finally** block, the finally block is always executed before control returns to the location of the call of the function.

5.2.2 Extension to ETSI ES 201 873-1, clause 16.1.3 (External Functions)

Clause 16.1.3 General

The syntax of external functions is extended with the optional **exception** clause.

Syntactical Structure

```
external function [ @deterministic | @control ] ExtFunctionIdentifier
"(" { ( FormalValuePar | FormalTemplatePar ) [ "," ] } ")"
[ return [ template [ Restriction ] ] Type ] [ exception "(" {Type [ "," ]}+ ")" ]
```

Clause 16.1.3 General

The semantic description part is extended.

External functions may have an exception list. The exception list declares, what exception types may be raised during the execution of the external function.

NOTE 0: The exception list can be used by tools to perform stronger static checks. For backward compatibility reasons the exception list is optional.

NOTE 1: The exception list might not be exhaustive. It might not be possible to precisely know what exceptions might be raised within an external function directly or indirectly.

5.2.3 Extension to ETSI ES 201 873-1, clause 16.1.4 (Invoking functions from specific places)

Clause 16.1.4 General

The list of restrictions is extended to avoid side effects.

- n) Raising an exception with the raise exception statement.

5.2.4 Extension to ETSI ES 201 873-1, clause 16.2 (Altsteps)

Clause 16.2.0 General

The syntax of altstep is extended with the optional **exception**, **catch** and **finally** clauses.

Syntactical Structure

```
altstep [ @control ] [ interleave ] AltstepIdentifier
"(" { ( FormalValuePar | FormalTemplatePar) ["," ] } ")"
[ runs on ComponentType ]
[ mtc ComponentType ]
[ system ComponentType ]
[ exception "(" {Type ["," ]+ } ")" ]
"{"
    { ( VarInstance | TimerInstance | ConstDef | TemplateDef ) [";"] }
    AltGuardList
"}"
{ CatchBlock }
[ FinallyBlock ]
```

Clause 16.2.0 General

The semantic description part is extended.

Altsteps may have an exception list. The exception list declares, what exception types may be raised during the execution of the altstep either directly or indirectly.

NOTE 0: The exception list can be used to communicate to the callers of the altstep what exceptions to prepare for and by tools to perform stronger static checks. For backward compatibility reasons the exception list is optional.

NOTE 1: The exception list might not be exhaustive. With activated altsteps it might not be possible to precisely know what exceptions might be raised within an altstep directly or indirectly.

Altsteps may have a finally block. If present the finally block is always executed before control returns to the location of the call of the altstep every time the altstep is invoked, regardless of whether implicitly as an activated default or explicitly from another alt statement.

5.2.5 Extension to ETSI ES 201 873-1, clause 16.3 (Test cases)

Clause 16.3 Test cases

The semantic description part is extended.

The StatementBlock of Test cases may have a finally block. If present the finally block is always executed before the test case terminates.

Exceptions raised directly or indirectly within the test case and not handled latest by the catch clauses of the StatementBlock of the testcase results in the testcase finishing with a dynamic error. In this situation the dynamic error has to reference not handling the exception as the reason of error.

NOTE 0: The reason for the dynamic error is not the raising of the exception, but the lack of handling within the testcase.

5.2.6 Extension to ETSI ES 201 873-1, clause 18 (Overview of program statements and operations)

The list of statements in table 15 of ETSI ES 201 873-1 needs to be extended with a raise exception statement as shown below.

Statement	Associated keyword or symbol	Can be directly or indirectly invoked by module control, but not by test components	Can be invoked by functions, test cases and altsteps running on test components	Can be directly or indirectly invoked from specific places (see note 1)
Expressions	(...)	Yes	Yes	Yes
Basic program statements				
Assignments	:=	Yes	Yes	Yes (see note 4)
If-else	if (...) {...} else {...}	Yes	Yes	Yes
Select case	select case (...) { case (...) {...} case else {...}}	Yes	Yes	Yes
For loop	for (...) {...}	Yes	Yes	Yes
While loop	while (...) {...}	Yes	Yes	Yes
Do while loop	do {...} while (...)	Yes	Yes	Yes
Label and Goto	label / goto	Yes	Yes	Yes
Stop execution	stop	Yes	Yes	
Returning control	return		Yes (see note 5)	Yes
Leaving a loop, alt, altstep or interleave	break	Yes	Yes	Yes
Next iteration of a loop	continue	Yes	Yes	Yes
Raise exception	raise	Yes	Yes	Yes
Logging	log	Yes	Yes	Yes
Statements and operations for alternative behaviours				
Alternative behaviour	alt {...}	Yes (see note 2)	Yes	
Re-evaluation of alternative behaviour	repeat	Yes	Yes	
Interleaved behaviour	interleave {...}	Yes (see note 2)	Yes	
Activate a default	activate	Yes	Yes	
Deactivate a default	deactivate	Yes	Yes	
Configuration operations				
Create parallel test component	create		Yes	
Connect component port to component port	connect		Yes	
Disconnect two component ports	disconnect		Yes	
Map port to test interface	map		Yes	
Unmap port from test system interface	unmap		Yes	
Get MTC component reference value	mtc		Yes	Yes
Get test system interface component reference value	system		Yes	Yes
Get own component reference value	self		Yes	Yes
Start execution of test component behaviour	start		Yes	
Stop execution of test component behaviour	stop		Yes	
Terminating the testcase with an error verdict	testcase.stop		Yes	Yes
Remove a test component from the system	kill		Yes	
Check termination of a PTC behaviour	running		Yes	
Check if a PTC exists in the test system	alive		Yes	
Wait for termination of a PTC behaviour	done		Yes	
Wait a PTC cease to exist	killed		Yes	

Statement	Associated keyword or symbol	Can be directly or indirectly invoked by module control, but not by test components	Can be invoked by functions, test cases and altsteps running on test components	Can be directly or indirectly invoked from specific places (see note 1)
Communication operations				
Send message	send		Yes	
Invoke procedure call	call		Yes	
Reply to procedure call from remote entity	reply		Yes	
Raise exception (to an accepted call)	raise		Yes	
Receive message	receive		Yes	
Trigger on message	trigger		Yes	
Accept procedure call from remote entity	getcall		Yes	
Handle response from a previous call	getreply		Yes	
Catch exception (from called entity)	catch		Yes	
Check (current) message/call received	check		Yes	
Clear port queue	clear		Yes	
Clear queue and enable sending & receiving at a to port	start		Yes	
Disable sending and disallow receiving operations to match at a port	stop		Yes	
Disable sending and disallow receiving operations to match new messages/calls	halt		Yes	
Check the state of a port	checkstate		Yes	
Timer operations				
Start timer	start	Yes	Yes	
Stop timer	stop	Yes	Yes	
Read elapsed time	read	Yes	Yes	
Check if timer running	running	Yes	Yes	
Timeout event	timeout	Yes	Yes	
Verdict operations				
Set local verdict	setverdict		Yes	
Get local verdict	getverdict		Yes	Yes
External actions				
Stimulate an (SUT) action externally	action	Yes	Yes	
Execution of test cases				
Execute test case	execute	Yes	Yes (see note 3)	
NOTE 1: Specific places are defined in clause 16.1.4. Only operations that do not have any potential side effects on snapshot evaluation are allowed.				
NOTE 2: Can be used to control timer operations only.				
NOTE 3: Can only be used in functions and altsteps that are used in module control.				
NOTE 4: Changing of component variables is disallowed.				
NOTE 5: Can be used in functions and altsteps but not in test cases.				

5.2.7 Extension to ETSI ES 201 873-1, clause 19 (Basic program statements)

Clause 19.0 General

The list of statements in table 17 needs to be extended with the raise exception statement as described below.

Basic program statements	
Statement	Associated keyword or symbol
Assignments	:=
If-else	if (...) {...} else {...}
Select case	select case (...) { case (...) {...} case else {...}
For loop	for (...) {...}
While loop	while (...) {...}
Do while loop	do {...} while (...)
Label and Goto	label / goto
Stop execution	stop
Returning control	return
Leaving a loop, alt, altstep or interleave	break
Next iteration of a loop	continue
Raise exception	raise
Logging	log

Clause 19.14 Statement Block

The syntax of statement block is changed as shown below.

```
BasicStatementBlock: "{" { LocalDefinition | Statement } }"
StatementBlock: BasicStatementBlock {catch "(" Type Identifier ")" BasicStatementBlock }
[finally BasicStatementBlock]
```

Clause 19.14 Statement Block

The semantic description part is extended.

A basic statement block is a sequence of declarations and statements.

Statement blocks can be used like basic program statements to introduce a local scope in the flow of control of TTCN-3 behaviour. The declarations and statements in a basic statement block are executed in the order of their appearance, i.e. sequentially.

A statement block consists of a basic statement block with optional additional catch clauses, that can be used to handle exceptions raised directly or indirectly within the basic statement block and an optional finally clause which is executed after the basic statement block execution. When an exception is raised by a statement in the basic statement block the catch clauses are tried in order of appearance to find one of the same type for data types or one the exception can be cast to if it is a type class kind exception. Execution continues with the basic stament block of the first catch clause whose type matches the type of the raised exception.

The catch clause declares a variable of an exception, with the type and identifier provided, to hold the value of the exception within the catch clause. The scope of this variable is limited to the basic statement block of the catch clause, i.e. it is only visible inside the body of the catch clause.

NOTE: The scope of the catch and finally blocks is on the same level with the scope of the basic statement block. Local variables declared within the basic statement block are not visible in the catch and finally clauses.

Clause 19.14 Statement Block

The list of restrictions is extended:

- a) The control transfer statements **return**, and **raise** shall not be used in the **finally** clause. Functions that can raise exceptions shall not be called in the finally clause.
- b) The basic statement block of a **catch** clause shall obey the same semantic restrictions as the basic statement block it follows.

Clause 19 is extended with a new clause.

NEW: Clause 19.15 The Raise exception statement

The **raise** exception statement raises an exception, causing the execution to continue at the catch block closest in the procedure call hierarchy, also executing all **finally** blocks it encounters while traversing the procedure call hierarchy.

Syntactical Structure

raise TemplateInstance

Semantic Description

The **raise** statement is used to raise an exception. On executing a **raise** exception statement the statement blocks, loops, **alt** statements or **interleave** statement within the encompassing function/altstep/testcase are left. If the encompassing function, altstep or testcase has a catch block with the exact same type as that of the raised exception value for data types or one the exception can be cast to if it is a class type exception, execution continues in that catch block. If the encompassing function or altstep does not have catch blocks or none of the catch blocks can handle the raised exception, execution leaves the function or altstep to handle the exception in the calling function, altstep or testcase. An exception not handled via catch clause of the StatementBlock of a testcase shall cause a dynamic error.

If the StatementBlock of a function, altstep or testcase has a finally block, this finally block is always executed before the function, altstep, testcase terminates. If an exception was raised and handled in a catch block, the finally block is executed after the catch block. If there was no exception raised, or an exception was raised but not handled in any catch blocks the finally block is executed before the function, altstep or testcase terminates.

The parameter of the **raise** operation shall evaluate to a value, that the exception will have.

Exceptions are specified as types. Therefore the exception value may either be derived from a template conforming to the template(value) restriction or be the value resulting from an expression (which of course can be an explicit value). The type of the value specification to the **raise** operation shall be determinable as it is necessary to avoid any ambiguity of the type of the value being raised.

NOTE 0: The type of the raised exception should be provided explicitly for literal values. Catch clauses with synonym types or restricted types will only catch exceptions of the same type.

Restrictions

In addition to the general static rules of TTCN-3 given in clause 5 and shown in table 15, the following restrictions apply:

- a) An exception shall only be raised inside a function, altstep or testcase.
- b) The *TemplateInstance* shall conform to the template(value) restriction (see clause 15.8).
- c) Exceptions shall not be raised directly or indirectly inside finally blocks of functions, altsteps or testcases.

Examples**EXAMPLE 1:**

```
raise ( v_myVariable + v_yourVariable - 2);
// Raises an exception with a value which is the result of the arithmetic expression

raise integer:5;    // Raises an exception with the integer value 5

raise charstring:"Olala!";
// Raises an exception with the charstring value "Olala!"
```

EXAMPLE 2: Catching an exception raised in a called function.

```
type record of charstring t_registeredNames;
type component myComponent {
    var t_registerdNames v_registeredNames;
}
function f_init(in charstring name) exception (charstring, integer) runs on myComponent
{
    ...
    if (name_was_not_registered) {
        raise ("Could not initialize " & name); // when the exception is raised f_init teminates
    }
}
```

```

    }
    ...
}

function f_operation(in charstring user1, in charstring user2) exception (integer)
runs on myComponent {
    f_init(user1);
    f_init(user2);
    ...
} catch (charstring e) {
    // the exception is available for processing in the e variable
    // release resources and terminate function
} catch (integer e) {
    //there was some other issue
    // release resources
    raise e; /// the exception is raised again to be handled in the calling function
}

```

EXAMPLE 3: Finally is always executed.

```

function f_operation2(in charstring user1, in charstring user2) exception (charstring)
runs on myComponent {
    f_init(user1);
    f_init(user2);
    ...
} finally {
    // finally is executed wether there was an exception or not before the function terminates
}

```

EXAMPLE 4: The exception can travel through several functions in the call hierarchy until handled.

```

function f_operation3(in charstring user1, in charstring user2) exception (charstring)
runs on myComponent {
    f_operation2(user1, user2); // an exception is raised in f_init
    ...
} finally {
    // after the finally block in f_operation2 this finally block is also executed
    // the exception is not caught.
}

```

EXAMPLE 5: Exception not caught latest in a testcase is reported as dynamic error.

```

testcase t_myTest1() runs on myComponent {
    f_init("user1");
    f_init("unknown user");// bad argument will raise an exception in f_init
    ... // because of the raised exception execution continues in the finally block
} finally {
    ... // via the runs on component resources can be freed
    // as the exception is not caught dynamic error is reported
}

```

EXAMPLE 6: The type of the exception has to match the type of the catch clause exactly.

```

function f_example() exception (integer) {
    raise integer:5;
}

type integer MyIntegerSynonim;
type integer MyIntegerRange (0 .. 255);

function f_example2() {
    f_example();
} catch (MyIntegerRange e) {
    // The exception is not caught here.
    // The type of the raised exception and the type of the catch type has to be the same
} catch (MyIntegerSynonim e) {
    // The exception is not caught here.
    // The type of the raised exception and the type of the catch type has to be the same
} catch (integer e) {
    // As the exception raised in f_example was raise with the integer type it is handled here
}

```

6 TRI Extensions for the Package

6.1 Extensions to clause 5.3 of ETSI ES 201 873-5 Data interface

Clause 5.3.2 Communication

The clause is to be modified:

`TriExceptionType`

A value of type `TriExceptionType` is an encoded type and value of an exception that either is to be sent to the SUT or has been received from the SUT. This abstract type is used in procedure based TRI communication operations and raising exception during execution of external functions, constructors, destructors and methods.

Clause 5.3.4 Miscellaneous

The clause is to be extended:

`TriClassIdType`

A value of type `TriClassIdType` is the name of a class as specified in the TTCN-3 ATS.

`TriObjHandleType`

A value of type `TriObjHandle` contains platform-specific data allowing access to external objects.

6.2 Extensions to clause 5.6.3 of ETSI ES 201 873-5 Miscellaneous operations

Clause 5.6.3.4 triExternalCreate (TE → PA)

This clause is to be added:

Signature	TriStatusType triExternalCreate(in TriClassIdType classId, inout TriParameterListType parameterList, out TriObjHandleType createdObject)
In Parameters	classId identifier of the external class
Out Parameters	returnValue handle to the created object
InOutParameters	parameterList a list of encoded parameters for the indicated constructor. The parameters in parameterList are ordered as they appear in the TTCN-3 constructor declaration.
Return Value	The return status of the triExternalCreate operation. The return status indicates the local success (TRI_OK) or failure (TRI_Error) of the operation.
Constraints	This operation is called by the TE when it invokes a constructor specified in a class which is defined as external in TTCN-3. In the invocation of a triExternalCreate operation by the TE all <i>in</i> and <i>inout</i> constructor parameters contain encoded values. No error shall be indicated by the PA in case the value of any <i>out</i> parameter is non-null.
Effect	The PA shall implement the behaviour for each external class specified in the TTCN-3 ATS. On invocation of this operation, the PA shall invoke the constructor of a class indicated by the identifier classId. It shall access the specified <i>in</i> and <i>inout</i> constructor parameters in parameterList, create a new external object instance using the values of these parameters, and compute values for <i>inout</i> and <i>out</i> parameters in parameterList. The operation shall then return encoded values for all <i>inout</i> and <i>out</i> constructor parameters and a handle to the created external object. The triExternalCreate operation returns TRI_OK if the PA completes the constructor of the external class successfully, TRI_Error otherwise. In the latter case, the distinct value null shall be returned as the object handle. Note that whereas most of other TRI operations are considered to be non-blocking, the triExternalCreate operation is considered to be <i>blocking</i> . That means that the operation shall not return before the construction of the external object has been finished. External constructors have to be implemented carefully as they could cause deadlock of test component execution or even the entire test system implementation.

Clause 5.6.3.5 triExternalFinally (TE → PA)

This clause is to be added:

Signature	TriStatusType triExternalFinally(in TriObjHandleType handle)
In Parameters	handle handle to the object being destroyed
Return Value	The return status of the triExternalFinally operation. The return status indicates the local success (TRI_OK) or failure (TRI_Error) of the operation.
Constraints	This operation is called by the TE when it invokes a destructor specified in a class which is defined as external in TTCN-3.
Effect	The PA shall implement the behaviour for each external class specified in the TTCN-3 ATS which contains a destructor definition. On invocation of this operation, the PA shall invoke the destructor of the object whose handle is in the handle parameter. The triExternalFinally operation returns TRI_OK if the PA completes destruction of the external object successfully, TRI_Error otherwise. Note that whereas most of other TRI operations are considered to be non-blocking, the triExternalFinally operation is considered to be <i>blocking</i> . That means that the operation shall not return before the destruction of the external object has been finished. External destructors have to be implemented carefully as they could cause deadlock of test component execution or even the entire test system implementation.

Clause 5.6.3.6 triExternalMethod (TE → PA)

This clause is to be added:

Signature	TriStatusType triExternalMethod(in TriObjHandleType handle, in String methodName, inout TriParameterListType parameterList, out TriParameterType returnValue)
In Parameters	handle handle of the affected object; null for static methods methodName name of the called method
Out Parameters	returnValue (optional) encoded return value
InOutParameters	parameterList a list of encoded parameters for the indicated method. The parameters in parameterList are ordered as they appear in the TTCN-3 method declaration.
Return Value	The return status of the triExternalMethod operation. The return status indicates the local success (TRI_OK) or failure (TRI_Error) of the operation.
Constraints	This operation is called by the TE when it invokes a method specified in a class which is defined as external in TTCN-3. In the invocation of a triExternalMethod operation by the TE all <i>in</i> and <i>inout</i> parameters contain encoded values. No error shall be indicated by the PA in case the value of any <i>out</i> parameter is non-null.
Effect	The PA shall implement the behaviour for each method of all external classes specified in the TTCN-3 ATS. On invocation of this operation, the PA shall call a method methodName of an external object whose handle is in the handle paramer. It shall access the specified <i>in</i> and <i>inout</i> method parameters in parameterList, pass the values of these parameters to the called method, and compute values for <i>inout</i> and <i>out</i> parameters in parameterList. The operation shall then return encoded values for all <i>inout</i> and <i>out</i> method parameters and the encoded return value. If no return type has been defined for this method in the TTCN-3 ATS, the distinct value null shall be used for the latter. The triExternalMethod operation returns TRI_OK if the PA completes the method of the external object successfully, TRI_Error otherwise. Note that whereas most of other TRI operations are considered to be non-blocking, the triExternalMethod operation is considered to be <i>blocking</i> . That means that the operation shall not return before the method call has been finished. Methods of external classes have to be implemented carefully as they could cause deadlock of test component execution or even the entire test system implementation.

Clause 5.6.3.7 triRaiseException (PA → TE)

This clause is to be added:

Signature	void triExternalRaise(in TriExceptionType exc)
In Parameters	exc encoded exception to raise
Constraints	This operation can be called by the PA only during execution of triExternalFunction, triExternalCreate, triExternalFinally or triExternalMethod.
Effect	The operation raises an exception that can be later processed by the TE in the catch statement. The exception is provided in an enoded form. The TE performs decoding when the triExternalFunction, triExternalCreate, triExternalFinally or triExternalMethod where the exception was raised returns. Decoding is performed in the catch statement.

6.3 Extensions to clause 6 of ETSI ES 201 873-5 Java™ language mapping

Clause 6.3.3.20 TriObjHandleType

This clause is to be added.

TriClassIdType is mapped to the following interface:

```
// TRI IDL TriClassIdType
package org.etsi.ttcn.tri;
public interface TriClassId {
    public String toString();
    public String getClassName();
    public boolean equals(TriClassId id);
}
```

Methods:

- `toString`
Returns the string representation of the class as defined in TTCN-3 specification.
- `getClassName`
Returns the class identifier as defined in the TTCN-3 specification.
- `equals`
Compares `id` with this `TriClassId` for equality. Returns `true` if and only if both classes have the same class identifier, `false` otherwise.

Clause 6.3.3.20 TriObjHandleType

This clause is to be added.

TriObjHandleType is mapped to the `java.lang.Object` class.

Clause 6.3.3.21 TriObjHandleWrapper

This clause is to be added.

TriObjHandleWrapper is used in the `triExternalCreate` operation as a placeholder for the created object handle.

```
public interface TriObjHandleWrapper {
    public void setHandle(Object handle);
    public Object getHandle();
}
```

Methods:

- `setHandle`
Sets the contained object.
- `getHandle`
Gets the contained object.

Clause 6.5.3.1 TriPlatformPA

This clause is to be extended.

```
// TriPlatform
// TE -> PA
package org.etsi.ttcn.tri;
public interface TriPlatformPA {
    ...

    // Ref: TRI-Definition 5.6.3.4
    public TriStatus triExternalCreate(TriClassIdType classId,
        TriParameterList parameterList, TriObjHandleWrapper handle);

    // Ref: TRI-Definition 5.6.3.5
    public TriStatus triExternalFinally(Object handle);

    // Ref: TRI-Definition 5.6.3.6
    public TriStatus triExternalMethod(Object handle, String methodName,
        TriParameterList parameterList, TriParameter returnValue);
}
```

Clause 6.5.3.2 TriPlatformTE

This clause is to be extended.

```
// TriPlatform
// PA -> TE
package org.etsi.ttcn.tri;
public interface TriPlatformTE {
    ...

    // Ref: TRI-Definition 5.6.3.7
    public void triRaiseException(TriException exc);
}
```

6.4 Extensions to clause 7 of ETSI ES 201 873-5 ANSI C language mapping

Clause 7.2.1 Abstract type mapping

This clause is to be extended.

TRI ADT	ANSI C Representation	Notes and comments
...		
TriClassIdType	QualifiedName	
TriObjectHandleType	typedef void * TriObjectHandle;	

Clause 7.2.4 TRI operation mapping

This clause is to be extended.

IDL Representation	ANSI C Representation
...	
TriStatusType triExternalCreate (in TriClassIdType classId, inout TriParameterListType parameterList, out TriObjHandleType createdObject)	TriStatus triExternalCreate (const TriClassId* classId, TriParameterList* parameterList, TriObjectHandle* handle)
TriStatusType triExternalFinally (in TriObjHandleType handle)	TriStatus triExternalFinally (TriObjectHandle handle)
TriStatusType triExternalMethod(in TriObjHandleType handle, in String methodName, inout TriParameterListType parameterList, out TriParameterType returnValue)	TriStatus triExternalFunction (TriClassId handle, char* methodName, TriParameterList* parameterList, TriParameter* returnValue)
void triRaiseException(in TriExceptionType exc)	void triRaiseException(const TriException* exc)

6.5 Extensions to clause 8 of ETSI ES 201 873-5 C++ language mapping

Clause 8.5.19 TriClassId

This clause is to be added.

A value of type TriClassIdType represents the name of a class as specified in the TTCN-3 ATS. It is a derived class from QualifiedName, mapped to the following pure virtual class:

```
class TriClassId : public QualifiedName {
public:
    virtual ~TriClassId ();
    virtual Tboolean operator== (const TriClassId &sid) const =0;
    virtual TriClassId * cloneClassId () const =0;
    virtual Tboolean operator< (const TriClassId &sid) const =0;
}
```

Methods:

- `~TriClassId`
Destructor.
- `operator==`
Returns true if both `TriClassId` objects are equal.
- `cloneClassId`
Returns a copy of the `TriClassId`.
- `operator<`
Operator `<` overload.

Clause 8.5.20 TriObjectHandle

This clause is to be added.

A value of type `TriObjectHandle` type is mapped to a void pointer:

```
typedef void * TriObjectHandle;
```

Clause 8.6.3 TriPlatformPA

This clause is to be extended.

```
class TriPlatformPA {
public:
    ...

    //For each constructor on an external class specified in the TTCN-3 ATS implement the behaviour.
    virtual TriStatus triExternalCreate (const TriClassId *classId, TriParameterList
    *parameterList, TriObjectHandle * handle)=0;

    //For each destructor on an external class specified in the TTCN-3 ATS implement the behaviour.
    virtual TriStatus triExternalCreate (TriObjectHandle handle)=0;

    //For each method on an external class specified in the TTCN-3 ATS implement the behaviour.
    virtual TriStatus triExternalMethod (TriObjectHandle handle, const Tstring & methodName,
    TriParameterList *parameterList, TriParameter *returnValue)=0;
}
```

Clause 8.6.4 TriPlatformTE

This clause is to be extended.

```
class TriPlatformTE {
public:
    ...

    //Raises an exception during execution of external code in PA
    virtual void triRaiseException (const TriException *exc)=0;
}
```

6.6 Extensions to clause 9 of ETSI ES 201 873-5 C# language mapping

Clause 9.4.2.19 TriClassId

This clause is to be added.

TriClassIdType C# mapping is derived from the `IQualifiedName` interface:

```
public interface ITriClassId : IQualifiedName {}
```

Clause 9.4.2.20 TriObjectHandleType mapping

This clause is to be added.

TriObjectHandleIdType is mapped to the C# object class.

Clause 9.5.2.3 TriPlatformPA

This clause is to be extended.

```
public interface ITriPlatformPA {
    ...

    // Miscellaneous operations
    // Ref: TRI-Definition clause 5.6.3.4
    TriStatus TriExternalCreate(ITriClassId classId,
        ITriParameterList parameterList, out object handle);

    // Ref: TRI-Definition clause 5.6.3.5
    TriStatus TriExternalFinally(object handle);

    // Ref: TRI-Definition clause 5.6.3.6
    TriStatus TriExternalMethod(object handle, string methodName,
        ITriParameterList parameterList, ITriParameter returnValue);
}
```

Clause 9.5.2.4 TriPlatformTE

This clause is to be extended.

```
public interface ITriPlatformTE {
    ...

    // Ref: TRI Definition clause 5.6.3.7
    void TriRaiseException(ITriException exc);
}
```

7 TCI Extensions for the Package

7.1 Extensions to clause 7.2.2.1 of ETSI ES 201 873-6 Abstract TTCN-3 data types and values

The definition of the `getTypeClass` operation shall be modified of the following way:

<code>TciTypeClassType</code> <code>getTypeClass()</code>	Returns the type class of the respective type. A value of <code>TciTypeClassType</code> can have one of the following constants: ADDRESS, ANYTYPE, ARRAY, BITSTRING, BOOLEAN, CHARSTRING, COMPONENT, ENUMERATED, FLOAT, HEXSTRING, INTEGER, OCTETSTRING, RECORD, RECORD_OF, SET, SET_OF, UNION, UNIVERSAL_CHARSTRING, VERDICT, DEFAULT, PORT, TIMER, CLASS.
---	---

7.2 Extensions to clause 7.2.2 of ETSI ES 201 873-6 Abstract TTCN-3 data types and values

Clause 7.2.2.5 Abstract TTCN-3 classes

This clause is to be added.

According to the present document, TTCN-3 user-defined classes will be represented at the TCI interfaces using the abstract data type `Class`. The abstract data type `Class` is based on the abstract data type `Type`.

The following operations defined for abstract data type `Type` work differently in the abstract data type `Class`:

<code>Value</code> <code>newInstance()</code>	The method creates an <code>ObjectInstance</code> containing a reference to a null object of the class.
---	---

The following operations are defined for abstract data type `Class`:

<code>ObjectInstance create(TriComponentIdType c, TciParameterListType tciPars)</code>	Calls the constructor to create a new instance of this class using the supplied parameters for the specified component. Created objects are always considered to be initialized.
<code>ClassSeq getSuperclasses ()</code>	Returns the superclasses of the current class.
<code>TStringSeq getFieldNames ()</code>	Returns the names of all public fields defined in the class.
<code>TStringSeq getMethodNames ()</code>	Returns the names of all public methods of the class.
<code>TciParameterTypeListType getConstructorParameters ()</code>	Returns formal parameters of the class constructor.
<code>TciParameterTypeListType getMethodParameters (TString methodName)</code>	Returns formal parameters of the specified public method. The distinct value <code>null</code> is returned if the method does not exist or is not public.
<code>Type getFieldTypes (TString name)</code>	Returns the type of the specified public field. The distinct value <code>null</code> is returned if the member variable does not exist or is not public.
<code>Type getMethodReturnType (TString name)</code>	Returns the return type of specified public method or the distinct value <code>null</code> if no return value is defined, the method does not exist or it is not public.

Clause 7.2.2.6 `ClassSeq`

This clause is to be added.

The abstract data type `ClassSeq` is used to represent a list of classes.

7.3 Extensions to clause 7.2.2.2.0 of ETSI ES 201 873-6 Basic rules

The figure 4 is to be extended.

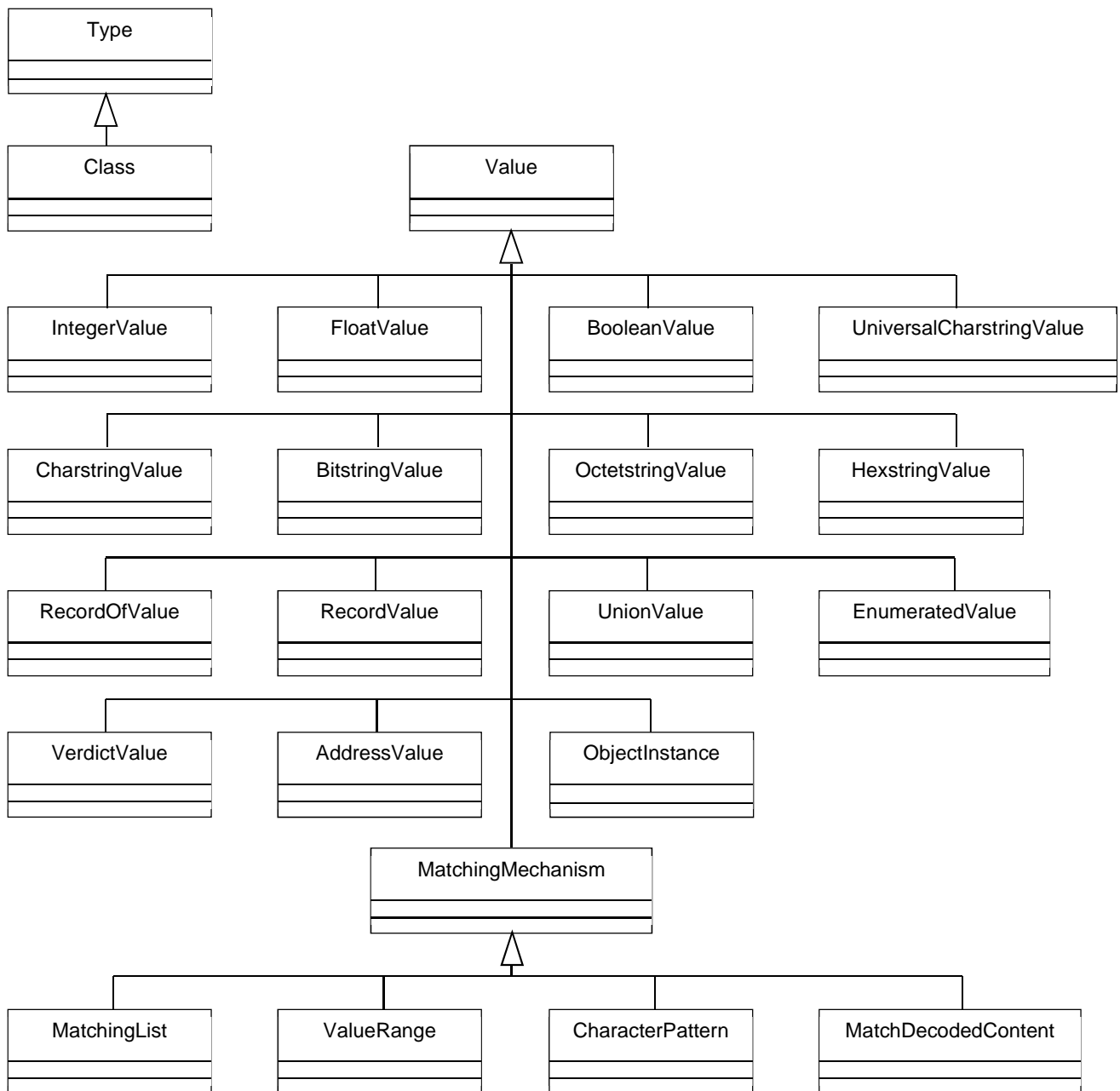


Figure 4: Hierarchy of abstract values

7.4 Extensions to clause 7.2.2.2 of ETSI ES 201 873-6 Abstract TTCN-3 values

Clause 7.2.2.16 The abstract data type ObjectInstance

This clause is to be added.

The abstract data type `ObjectInstance` is based on the abstract data type `Value`. It is used to modify the referenced object and to access public object fields and methods.

The following operations are defined on the abstract data type `ObjectInstance`:

<code>TriComponentIdType getOwner ()</code>	Returns the component that owns the object instance.
<code>TString getId ()</code>	Returns an identifier of the object which is unique within the owner component context.

`void setObject (ObjectInstance source)`

The operation sets the referenced object to be the same one as the one referenced by the `source` parameter. In case the source object does not contain a null reference, the object instance and the source object shall be owned by the same component.

Value `getField (TString fieldName)`

Returns the value of the referenced public member field. The distinct value `null` is returned if the object does not contain the referenced field or the field is not accessible.

Value `callMethod(TString methodName, TciParameterListType tciPars)`

Calls the method of the object instance. The distinct value `null` is returned if the method does not return any value. A runtime error is generated if the method does not exist or if the given parameters do not conform to the formal parameters of the declared method.

7.5 Extensions to clause 7.3.4.1 of ETSI ES 201 873-6 Abstract TCI-TL provided

Clause 7.3.4.1.122 `tliObjCreateEnter`

This clause is to be added.

Signature	<code>void tliObjCreateEnter(in TString am, in TInteger ts, in TString src, in TInteger line, in TriComponentIdType c, in ObjectInstance obj, in TciParameterListType tciPars)</code>	
In Parameters	<code>am</code>	An additional message.
	<code>ts</code>	The time when the event is produced.
	<code>src</code>	The source file of the test specification.
	<code>line</code>	The line number where the request is performed.
	<code>c</code>	The component which produces this event.
	<code>obj</code>	The object being created.
	<code>tciPars</code>	The parameters of the constructor.
Return Value	<code>Void</code>	
Constraint	Shall be called by TE to log the entering of a constructor of an object. This event occurs after the constructor has been entered.	
Effect	The TL presents all the information provided in the parameters of this operation to the user, how this is done is not within the scope of the present document.	

Clause 7.3.4.1.123 `tliObjCreateLeave`

This clause is to be added.

Signature	<code>void tliObjCreateLeave(in TString am, in TInteger ts, in TString src, in TInteger line, in TriComponentIdType c, in ObjectInstance obj, in TciParameterListType tciPars)</code>	
In Parameters	<code>am</code>	An additional message.
	<code>ts</code>	The time when the event is produced.
	<code>src</code>	The source file of the test specification.
	<code>line</code>	The line number where the request is performed.
	<code>c</code>	The component which produces this event.
	<code>obj</code>	The created object instance.
	<code>tciPars</code>	The parameters of the constructor.
Return Value	<code>Void</code>	
Constraint	Shall be called by TE to log the leaving of an object constructor. This event occurs after the constructor has been left.	
Effect	The TL presents all the information provided in the parameters of this operation to the user, how this is done is not within the scope of the present document.	

Clause 7.3.4.1.124 `tliObjFinallyEnter`

This clause is to be added.

Signature	void tliObjFinallyEnter(in TString am, in TInteger ts, in TString src, in TInteger line, in TriComponentIdType c, in ObjectInstance obj)	
In Parameters	am	An additional message.
	ts	The time when the event is produced.
	src	The source file of the test specification.
	line	The line number where the request is performed.
	c	The component which produces this event.
	obj	The object instance being destroyed.
Return Value	Void	
Constraint	Shall be called by TE to log the entering of a destructor of an object. This event occurs after the destructor has been entered.	
Effect	The TL presents all the information provided in the parameters of this operation to the user, how this is done is not within the scope of the present document.	

Clause 7.3.4.1.125 tliObjFinallyLeave

This clause is to be added.

Signature	void tliObjCreateLeave(in TString am, in TInteger ts, in TString src, in TInteger line, in TriComponentIdType c, in ObjectInstance obj, in TciParameterListType tciPars)	
In Parameters	am	An additional message.
	ts	The time when the event is produced.
	src	The source file of the test specification.
	line	The line number where the request is performed.
	c	The component which produces this event.
	obj	The object being destroyed.
Return Value	Void	
Constraint	Shall be called by TE to log the leaving of an object destructor. This event occurs after the destructor has been left. Accessing any members, properties and methods of a destroyed object with exception of methods used for comparison shall cause an error.	
Effect	The TL presents all the information provided in the parameters of this operation to the user, how this is done is not within the scope of the present document.	

Clause 7.3.4.1.126 tliObjMethodEnter

This clause is to be added.

Signature	void tliObjMethodEnter(in TString am, in TInteger ts, in TString src, in TInteger line, in TriComponentIdType c, in ObjectInstance obj, in TString methodName, in TciParameterListType tciPars)	
In Parameters	Am	An additional message.
	Ts	The time when the event is produced.
	src	The source file of the test specification.
	line	The line number where the request is performed.
	C	The component which produces this event.
	obj	The affected object instance.
	methodName	The name of the called method.
	tciPars	The parameters of the called method.
Return Value	void	
Constraint	Shall be called by TE to log the entering of an object method. This event occurs after the method has been entered.	
Effect	The TL presents all the information provided in the parameters of this operation to the user, how this is done is not within the scope of the present document.	

Clause 7.3.4.1.127 tliObjMethodLeave

This clause is to be added.

Signature	void tliObjMethodLeave(in TString am, in TInteger ts, in TString src, in TInteger line, in TriComponentIdType c, in ObjectInstance obj, in TString methodName, in TciParameterListType tciPars, in Value returnValue)	
In Parameters	Am	An additional message.
	Ts	The time when the event is produced.
	src	The source file of the test specification.
	line	The line number where the request is performed.
	C	The component which produces this event.
	obj	The affected object instance.
	methodName	The name of the called method.
	tciPars	The parameters of the called method.
Return Value	void	
Constraint	Shall be called by TE to log the leaving of an object method. This event occurs after the method has been left.	
Effect	The TL presents all the information provided in the parameters of this operation to the user, how this is done is not within the scope of the present document.	

Clause 7.3.4.1.132 tliObjVar

This clause is to be added.

Signature	void tliObjVar(in TString am, in TInteger ts, in TString src, in TInteger line, in TriComponentIdType c, in ObjectInstance obj, in TString name, in Value value)	
In Parameters	Am	An additional message.
	Ts	The time when the event is produced.
	Src	The source file of the test specification.
	Line	The line number where the request is performed.
	C	The component which produces this event.
	Obj	The affected object instance.
	name	The name of the member variable.
	value	The new value of the member variable.
Return Value	Void	
Constraint	Shall be called by TE to log the modification of the value of a field of an object. This event occurs after the field value has been changed. In case of @lazy fields, it is called also after performing evaluation as the evaluation result is automatically assigned to the field.	
Effect	The TL presents all the information provided in the parameters of this operation to the user, how this is done is not within the scope of the present document.	

7.6 Extensions to clause 8 of ETSI ES 201 873-6 Java™ language mapping

Clause 8.3.2.4 TciTypeClassType

This clause is to be extended.

TciTypeClassType is mapped to the following interface:

```
// TCI IDL TciTypeClassType
package org.etsi.ttcn.tci;
public interface TciTypeClass {
    public final static int ADDRESS           = 0 ;
    public final static int ANYTYPE          = 1 ;
    public final static int BITSTRING        = 2 ;
    public final static int BOOLEAN          = 3 ;
    public final static int CHARSTRING       = 5 ;
    public final static int COMPONENT        = 6 ;
    public final static int ENUMERATED       = 7 ;
    public final static int FLOAT             = 8 ;
    public final static int HEXSTRING        = 9 ;
    public final static int INTEGER          = 10 ;
    public final static int OCTETSTRING      = 12 ;
    public final static int RECORD           = 13 ;
}
```

```

public final static int RECORD_OF           = 14 ;
public final static int ARRAY               = 15 ;
public final static int SET                 = 16 ;
public final static int SET_OF             = 17 ;
public final static int UNION              = 18 ;
public final static int UNIVERSAL_CHARSTRING = 20 ;
public final static int VERDICT           = 21 ;
public final static int DEFAULT           = 22 ;
public final static int PORT              = 23 ;
public final static int TIMER             = 24 ;
public final static int CLASS             = 25 ;
}

```

Clause 8.3.6.7 Abstract class mapping

This clause is to be added.

Class is mapped to the following interface:

```

// TCI IDL Type
package org.etsi.ttcn.tci;
public interface Class extends Type {
    public ObjectInstance create (TriComponentId c, TciParameterList tciPars);
    public Class[]      getSuperclasses ();
    public String[]     getFieldNames ();
    public String[]     getMethodNames ();
    public TciParameterTypeList getConstructorParameters ();
    public TciParameterTypeList getMethodParameters (String methodName);
    public Type         getFieldTypes (String name);
    public Type         getMethodReturnType (String methodName);
}

```

Methods:

- `create` Calls the constructor to create a new instance of this class using the supplied parameters for the specified component.
- `getSuperclasses` Returns the list of superclasses of this class.
- `getFieldNames` Returns the names of all public fields defined in the class.
- `getMethodNames` Returns the names of all public methods of the class.
- `getConstructorParameters` Returns the formal parameters of the class constructor.
- `getMethodParameters` Returns the formal parameters of the specified public method.
- `getFieldType` Returns the type of the specified public field.
- `getMethodReturnType` Returns the return type of specified public method or the distinct value null if no return type is declared.

Clause 8.3.6.8 ClassSeq

This clause is to be added.

ClassSeq abstract data type mapped to an array of `TciClass`.

Clause 8.3.4.16 ObjectInstance

This clause is to be added.

ObjectInstance is mapped to the following interface:

```

// TCI IDL DynamicMatch
package org.etsi.ttcn.tci;
public interface ObjectInstance extends Value {
    public TriComponentId getOwner ();
    public TString      getId ();
    public void         setObject (ObjectInstance source);
    public Value        callMethod (String methodName, TciParameterList tciPars);
}

```

Methods:

- `getOwner` Returns the component that owns the object instance.
- `getId` Returns the unique identifier of the object instance.
- `setObject` The operation sets the referenced object to the same reference as the given object.
- `getField` Gets the value of the referenced public field.
- `callMethod` Calls a method of the object instance.

Clause 8.5.4.1 TCI-TL provided

The `TciTLProvided` interface is to be extended:

```
package org.etsi.ttcn.tci;
public interface TciTLProvided {
    ...
    public void tliObjCreateEnter(String am, int ts, String src, int line, TriComponentId c,
        ObjectInstance obj, TciParameterList tciPars);
    public void tliObjCreateLeave(String am, int ts, String src, int line, TriComponentId c,
        ObjectInstance obj, TciParameterList tciPars);
    public void tliObjFinallyEnter(String am, int ts, String src, int line, TriComponentId c,
        ObjectInstance obj);
    public void tliObjFinallyLeave(String am, int ts, String src, int line, TriComponentId c,
        ObjectInstance obj);
    public void tliObjMethodEnter(String am, int ts, String src, int line, TriComponentId c,
        ObjectInstance obj, String methodName, TciParameterList tciPars);
    public void tliObjMethodLeave(String am, int ts, String src, int line, TriComponentId c,
        ObjectInstance obj, String methodName, TciParameterList tciPars, Value returnValue);
    public void tliObjVar(String am, int ts, String src, int line, TriComponentId c,
        ObjectInstance obj, String name, Value value);
}

```

7.7 Extensions to clause 9 of ETSI ES 201 873-6 ANSI C language mapping

Clause 9.2 Data

The table 5 is to be extended.

TCI IDL Interface	ANSI C representation	Notes and comments
:		
Class		
Value <code>create(TriComponentIdType c, TciParameterListType tciPars)</code>	Value <code>tciObjCreate(Type cls, TriComponentId c, TciParameterListType tciPars)</code>	
ClassSeq <code>getSuperclasses ()</code>	Type* <code>tciGetSuperclasses (Type cls)</code>	Returns null pointer or a null-pointer terminated array
TStringSeq <code>getFieldNames ()</code>	String* <code>tciGetClassFieldNames (Type cls)</code>	Returns null pointer or a null-pointer terminated array
TStringSeq <code>getMethodNames ()</code>	String* <code>tciGetClassMethodNames (Type cls)</code>	Returns null pointer or a null-pointer terminated array
TciParameterTypeListType <code>getConstructorParmeters ()</code>	TciParameterTypeListType* <code>tciGetClassConstructorParameters (Type cls)</code>	
TciParameterTypeListType <code>getMethodParameters (TString methodName)</code>	TciParameterTypeListType* <code>tciGetClassMethodParameters (Type cls, String methodName)</code>	
Type <code>getMemberType (TString name)</code>	Type <code>tciGetClassFieldType (Type cls, String name)</code>	
Type <code>getMethodReturnType (TString methodName)</code>	Type <code>tciGetClassMethodReturnType (Type cls, String methodName)</code>	
ObjectInstance		
TriComponentIdType <code>getOwner ()</code>	TriComponentId <code>tciGetObjOwner (Value obj)</code>	

TCI IDL Interface	ANSI C representation	Notes and comments
TString getId ()	char * tciGetObjUniqueId (Value obj)	
void setObject (ObjectInstance source)	void tciSetObject (Value obj, Value source)	
Value getField (TString fieldName)	Value tciGetObjField (Value obj, String fieldName)	
Value callMethod(TString methodName, TciParameterListType tciPars)	Value tciCallObjMethod(Value obj, String methodName, TciParameterListType tciPars)	

Clause 9.4.4.1 TCI-TL provided

The clause is to be extended.

```

void tliObjCreateEnter
  (String am, int ts, String src, int line, TriComponentId c, Value obj,
   TciParameterListType tciPars);
void tliObjCreateLeave
  (String am, int ts, String src, int line, TriComponentId c, Value obj,
   TciParameterListType tciPars);
void tliObjFinallyEnter
  (String am, int ts, String src, int line, TriComponentId c, Value obj);
void tliObjFinallyLeave
  (String am, int ts, String src, int line, TriComponentId c, Value obj);
void tliObjMethodEnter
  (String am, int ts, String src, int line, TriComponentId c, Value obj, String methodName,
   TciParameterListType tciPars);
void tliObjMethodLeave
  (String am, int ts, String src, int line, TriComponentId c, Value obj, String methodName,
   TciParameterListType tciPars, Value returnValue);
void tliObjVar
  (String am, int ts, String src, int line, TriComponentId c, Value obj, String name,
   Value value);

```

Clause 9.5 Data

The definition of the TciTypeClassType in the table 7 is to be modified.

TCI IDL ADT	ANSI C representation (Type definition)	Notes and comments
:		
TciTypeClassType	<pre> typedef enum { TCI_ADDRESS_TYPE = 0, TCI_ANYTYPE_TYPE = 1, TCI_BITSTRING_TYPE = 2, TCI_BOOLEAN_TYPE = 3, TCI_CHARSTRING_TYPE = 5, TCI_COMPONENT_TYPE = 6, TCI_ENUMERATED_TYPE = 7, TCI_FLOAT_TYPE = 8, TCI_HEXSTRING_TYPE = 9, TCI_INTEGER_TYPE = 10, TCI_OCTETSTRING_TYPE = 12, TCI_RECORD_TYPE = 13, TCI_RECORD_OF_TYPE = 14, TCI_ARRAY_TYPE = 15, TCI_SET_TYPE = 16, TCI_SET_OF_TYPE = 17, TCI_UNION_TYPE = 18, TCI_UNIVERSAL_CHARSTRING_TYPE = 20, TCI_VERDICT_TYPE = 21, TCI_DEFAULT_TYPE = 22, TCI_PORT_TYPE = 23, TCI_TIMER_TYPE = 24, TCI_CLASS_TYPE = 25 } TciTypeClassType; </pre>	
:		

7.8 Extensions to clause 10 of ETSI ES 201 873-6 C++ language mapping

Clause 10.5.2.14 TciTypeClass

This clause is to be extended.

```
typedef enum
{
    TCI_ADDRESS = 0,
    TCI_ANYTYPE = 1,
    TCI_BITSTRING = 2,
    TCI_BOOLEAN = 3,
    TCI_CHARSTRING = 5,
    TCI_COMPONENT = 6,
    TCI_ENUMERATED = 7,
    TCI_FLOAT = 8,
    TCI_HEXSTRING = 9,
    TCI_INTEGER = 10,
    TCI_OCTETSTRING = 12,
    TCI_RECORD = 13,
    TCI_RECORD_OF = 14,
    TCI_ARRAY = 15,
    TCI_SET = 16,
    TCI_SET_OF = 17,
    TCI_UNION = 18,
    TCI_UNIVERSAL_CHARSTRING = 20,
    TCI_VERDICT = 21,
    TCI_DEFAULT = 22,
    TCI_PORT = 23,
    TCI_TIMER = 24,
    TCI_CLASS = 25
} TciTypeClass;
```

Clause 10.5.3.23 Class

This clause is to be added.

TTCN-3 class support. It is mapped to the following pure virtual class:

```
class TciClass : public virtual TciType {
public:
    virtual ~TciClass ();
    virtual ObjectInstance * create(const TriComponentId & c, TciParameterList & tciPars) =0;
    virtual const std::vector<TciClass*> & getSuperclasses () const =0;
    virtual const std::vector<Tstring*> & getFieldNames () const =0;
    virtual const std::vector<Tstring*> & getMethodNames () const =0;
    virtual const TciParameterTypeList & getConstructorParameters () const =0;
    virtual const TciParameterTypeList & getMethodParameters (Tstring methodName) const =0;
    virtual const TciType & getMemberType (const Tstring & name) const =0;
    virtual const TciType & getMethodReturnValue (const Tstring & name) const =0;
    virtual Tboolean operator== (const TciClass &p_class) const =0;
    virtual TciClass * clone () const =0;
    virtual Tboolean operator< (const TciClass &p_content) const =0;
}
```

Methods:

~TciClass

Destructor

create

Calls the constructor to create a new instance of this class using the supplied parameters for the specified component

getSuperclasses

Returns the superclasses of the current class

getFieldNames

Returns the names of all public fields defined in the class

getMethodNames

Returns the names of all public methods of the class

getConstructorParameters

Returns formal parameters of the class constructor

getMethodParameters
Returns formal parameters of the specified public method

getFieldType
Returns the type of the specified public field

getMethodReturnValue
Returns the return type of specified public method or the distinct value null if no return value is defined

operator==
Returns true if both objects are equal

clone
Return a copy of the matching mechanism

operator<
Operator < overload

Clause 10.5.3.24 ObjectInstance

This clause is to be added.

TTCN-3 implication and exclusion matching mechanism support. It is mapped to the following pure virtual class:

```
class ObjectInstance : public virtual TciValue {
public:
    virtual ~ObjectInstance ();
    virtual const TriComponentId & getOwner () const =0;
    virtual const TString getId () const =0;
    virtual void setObject (ObjectInstance & val) =0;
    virtual TciValue * getField (const TString & fieldName) =0;
    virtual Value callMethod(const TString & methodName, TciParameterList & tciPars) =0;
    virtual Tboolean operator== (const ObjectInstance &p_obj) const =0;
    virtual ObjectInstance * clone () const =0;
    virtual Tboolean operator< (const ObjectInstance &p_content) const =0;
}
```

Methods:

~ObjectInstance
Destructor

getOwner
Returns the component that owns the object instance

getId
Returns the unique identifier of the object instance

setObject
The operation sets the referenced object

getField
Returns the value of the referenced public field

callMethod
Calls a method of the object instance

operator==
Returns true if both objects are equal

clone
Return a copy of the matching mechanism

operator<
Operator < overload

Clause 10.5.3.25 ClassSeq

This clause is to be added.

The ClassSeq abstract data type is mapped to `std::vector<TciClass*>`.

Clause 10.6.4.1 TciTIPProvided

This clause is to be extended.

```
//Called by TE to log the entering of a constructor
virtual void tliObjCreateEnter (const TString &am, const timeval ts, const TString &src, const
Tinteger line, const TriComponentId *c, const ObjectInstance *obj, const TciParameterList
*tciPars)=0;

//Called by TE to log the leaving of a constructor
virtual void tliObjCreateLeave (const TString &am, const timeval ts, const TString &src, const
Tinteger line, const TriComponentId *c, const ObjectInstance *obj, const TciParameterList
*tciPars)=0;
```



```

//Called by TE to log the entering of a destructor
virtual void tliObjFinallyEnter (const Tstring &am, const timeval ts, const Tstring &src, const
Tinteger line, const TriComponentId *c, const ObjectInstance *obj)=0;

//Called by TE to log the leaving of a destructor
virtual void tliObjFinallyLeave (const Tstring &am, const timeval ts, const Tstring &src, const
Tinteger line, const TriComponentId *c, const ObjectInstance *obj)=0;

//Called by TE to log the entering of an object method
virtual void tliObjMethodEnter (const Tstring &am, const timeval ts, const Tstring &src, const
Tinteger line, const TriComponentId *c, const ObjectInstance *obj, const Tstring &methodName, const
TciParameterList *tciPars)=0;

//Called by TE to log the leaving of an object method
virtual void tliObjMethodLeave (const Tstring &am, const timeval ts, const Tstring &src, const
Tinteger line, const TriComponentId *c, const ObjectInstance *obj, const Tstring &methodName, const
TciParameterList *tciPars, const TciValue *returnValue)=0;

//Called by TE to log the modification of a member variable of an object
virtual void tliObjVar (const Tstring &am, const timeval ts, const Tstring &src, const Tinteger
line, const TriComponentId *c, const ObjectInstance *obj, const Tstring &name, const TciValue
*value)=0;

```

7.9 Extensions to clause 11 of ETSI ES 201 873-6 W3C XML mapping

Clause 11.3.3.30 ObjectInstance

ObjectInstance type is mapped to the complex type specified below. The content of the XML elements based on the ObjectInstance type shall be equal to the string produced by the valueToString operation (described in clause 7.2.2.2.1 of ETSI ES 201 873-6 [4]):

```

<xsd:complexType name="ObjectInstance">
  <xsd:group ref="Values:BaseValue"/>
  <xsd:attributeGroup ref="Values:ValueAtts"/>
</xsd:complexType>

```

Items:

- BaseValue Object instance content described in clause 11.3.3.1 of ETSI ES 2001-873-6
- ValueAtts Value attributes described in clause 11.3.3.1 of ETSI ES 2001-873-6

Clause 11.4.2.1 TCI-TL provided

This clause is to be extended.

```

<xsd:complexType name="tliObjCreateEnter">
  <xsd:complexContent mixed="true">
    <xsd:extension base="Events:Event">
      <xsd:sequence>
        <xsd:element name="obj" type="Values:ObjectInstance" />
        <xsd:element name="tciPars" type="Types:TciParameterListType" minOccurs="0"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:complexType name="tliObjCreateLeave">
  <xsd:complexContent mixed="true">
    <xsd:extension base="Events:Event">
      <xsd:sequence>
        <xsd:element name="obj" type="Values:ObjectInstance" />
        <xsd:element name="tciPars" type="Types:TciParameterListType" minOccurs="0"/>
        <xsd:element name="returnValue" type="Values:Value" minOccurs="0"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:complexType name="tliObjFinallyEnter">
  <xsd:complexContent mixed="true">

```

```

    <xsd:extension base="Events:Event">
      <xsd:sequence>
        <xsd:element name="obj" type="Values:ObjectInstance" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:complexType name="tliObjFinallyLeave">
  <xsd:complexContent mixed="true">
    <xsd:extension base="Events:Event">
      <xsd:sequence>
        <xsd:element name="obj" type="Values:ObjectInstance" />
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:complexType name="tliObjMethodEnter">
  <xsd:complexContent mixed="true">
    <xsd:extension base="Events:Event">
      <xsd:sequence>
        <xsd:element name="obj" type="Values:ObjectInstance" />
        <xsd:element name="methodName" type="SimpleTypes:TString" />
        <xsd:element name="tciPars" type="Types:TciParameterListType" minOccurs="0"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:complexType name="tliObjMethodLeave">
  <xsd:complexContent mixed="true">
    <xsd:extension base="Events:Event">
      <xsd:sequence>
        <xsd:element name="obj" type="Values:ObjectInstance" />
        <xsd:element name="methodName" type="SimpleTypes:TString" />
        <xsd:element name="tciPars" type="Types:TciParameterListType" minOccurs="0"/>
        <xsd:element name="returnValue" type="Values:Value" minOccurs="0"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

<xsd:complexType name="tliObjVar">
  <xsd:complexContent mixed="true">
    <xsd:extension base="Events:Event">
      <xsd:sequence>
        <xsd:element name="obj" type="Values:ObjectInstance" />
        <xsd:element name="name" type="SimpleTypes:TString" />
        <xsd:element name="val" type="Values:Value" minOccurs="0"/>
      </xsd:sequence>
    </xsd:extension>
  </xsd:complexContent>
</xsd:complexType>

```

7.10 Extensions to clause 12 of ETSI ES 201 873-6 C# language mapping

Clause 12.4.2.4 TciTypeClassType

This clause is to be extended.

TciTypeClassType is mapped to the following enumeration:

```

public enum TciTypeClass {
  Address = 0,
  Anytype = 1,
  Bitstring = 2,
  BooleanType = 3,
  Charstring = 5,
  Component = 6,
  Enumerated = 7,
  Float = 8,
  Hexstring = 9,

```

```

IntegerType = 10,
Octetstring = 12,
Record = 13,
RecordOf = 14,
Array = 15
Set = 16,
SetOf = 17,
Union = 18,
UniversalCharstring = 20,
Verdict = 21,
Default = 22,
Port = 23,
Timer = 24,
Class = 25
}

```

Clause 12.4.7 Abstract class mapping

This clause is to be added.

The IDL type **Class** is mapped to the following interface:

```

// TCI IDL Type
package org.etsi.ttcn.tci;
public interface ITciClass : ITciType {
    ITciObjectInstance Create (ITriComponentId c, ITciParameterList tciPars);
    ITciClass[] Superclasses { get; }
    String[] FieldNames { get };
    String[] MethodNames { get; }
    ITciParameterTypeList ConstructorParameters { get; }
    ITciParameterTypeList GetMethodParameters (String methodName);
    ITciType GetFieldType (String name);
    ITciType GetMethodReturnType (String methodName);
}

```

Methods:

- **Create** Calls the constructor to create a new instance of this class using the supplied parameters for the specified component.
- **Superclasses** Returns the list of superclass of the current.
- **FieldNames** Returns the names of all public fields defined in the class.
- **MethodNames** Returns the names of all public methods of the class.
- **ConstructorParameters** Returns formal parameters of the class constructor.
- **GetMethodParameters** Returns formal parameters of the specified public method.
- **GetFieldType** Returns the type of the specified public field.
- **GetMethodReturnType** Returns the return type of specified public method or the distinct value null if no return value is defined.

Clause 12.4.8 ClassSeq mapping

This clause is to be added.

The **ClassSeq** abstract data type is mapped to **ITciClass[]**.

Clause 12.4.4.16 ObjectInstance

This clause is to be added.

The IDL type **ObjectInstance** is mapped to the following interface:

```

public interface ITciObjectInstance : ITciValue {
    ITciComponentId Owner { get; }
    String Id { get; }
    void SetObject (ITciObjectInstance source);
    ITciValue GetField (String fieldName);
}

```

```

    ITciValue      CallMethod (String methodName, ITciParameterList tciPars);
}

```

Methods:

- Owner Returns the component that owns the object instance.
- Id Returns the unique identifier of the object instance.
- SetObject The operation sets the referenced object.
- GetField Returns the value of the referenced public field.
- CallMethod Calls a method of the object instance.

Clause 12.5.4.1 TCI-TL provided

The ITciTLProvided interface is to be extended:

```

public interface ITciTLProvided {
    ...
    void TliObjCreateEnter(string am, System.DateTime ts, string src, int line,
        ITriComponentId c, ITciObjectInstance obj, ITciParameterList tciPars);
    void TliObjCreateLeave(string am, System.DateTime ts, string src, int line,
        ITriComponentId c, ITciObjectInstance obj, ITciParameterList tciPars);
    void TliObjFinallyEnter(string am, System.DateTime ts, string src, int line,
        ITriComponentId c, ITciObjectInstance obj);
    void TliObjFinallyLeave(string am, System.DateTime ts, string src, int line,
        ITriComponentId c, ITciObjectInstance obj);
    void TliObjMethodEnter(string am, System.DateTime ts, string src, int line,
        ITriComponentId c, ITciObjectInstance obj, string methodName, ITciParameterList tciPars);
    void TliObjMethodLeave(string am, System.DateTime ts, string src, int line,
        ITriComponentId c, ITciObjectInstance obj, string methodName, ITciParameterList tciPars,
        ITciValue returnValue);
    void TliObjVar (string am, System.DateTime ts, string src, int line,
        ITriComponentId c, ITciObjectInstance obj, string name, ITciValue value);
}

```

8 XTRI Extensions for the Package (optional)

8.1 Changes to clause 5.6.3 of ETSI ES 201 873-5 Miscellaneous operations

Clause 5.6.3.4 triExternalCreate → xtriExternalCreate

Signature	TriStatusType xtriExternalCreate(in TriClassIdType classId, inout TciParameterListType parameterList, out TriObjHandleType createdObject)
In Parameters	classId identifier of the external class
Out Parameters	createdObject handle to the created object
InOutParameters	parameterList a list of encoded parameters for the indicated constructor. The parameters in parameterList are ordered as they appear in the TTCN-3 constructor declaration.
Return Value	The return status of the xtriExternalCreate operation. The return status indicates the local success (TRI_OK) or failure (TRI_Error) of the operation.
Constraints	This operation is called by the TE when it invokes a constructor specified in a class which is defined as external in TTCN-3. In the invocation of a triExternalCreate operation by the TE all <i>in</i> and <i>inout</i> constructor parameters contain encoded values. No error shall be indicated by the PA in case the value of any <i>out</i> parameter is non-null.

Effect	<p>The PA shall implement the behaviour for each external class specified in the TTCN-3 ATS. On invocation of this operation, the PA shall invoke the constructor of a class indicated by the identifier <code>classId</code>. It shall access the specified <i>in</i> and <i>inout</i> constructor parameters in <code>parameterList</code>, create a new external object instance using the values of these parameters, and compute values for <i>inout</i> and <i>out</i> parameters in <code>parameterList</code>. The operation shall then return encoded values for all <i>inout</i> and <i>out</i> constructor parameters and a handle to the created external object.</p> <p>The <code>xtriExternalCreate</code> operation returns TRI_OK if the PA completes the constructor of the external class successfully, TRI_Error otherwise. In the latter case, the distinct value <code>null</code> shall be returned as the object handle.</p> <p>Note that whereas most of other TRI operations are considered to be non-blocking, the <code>xtriExternalCreate</code> operation is considered to be <i>blocking</i>. That means that the operation shall not return before the construction of the external object has been finished. External constructors have to be implemented carefully as they could cause deadlock of test component execution or even the entire test system implementation.</p>
---------------	--

Clause 5.6.3.6 `triExternalMethod` → `xtriExternalMethod`

Signature	<pre>TriStatusType xtriExternalMethod(in TriObjHandleType handle, in String methodName, inout TciParameterListType parameterList, out TciParameterType returnValue)</pre>				
In Parameters	<table> <tr> <td><code>handle</code></td> <td>handle of the affected object; null for static methods</td> </tr> <tr> <td><code>methodName</code></td> <td>name of the called method</td> </tr> </table>	<code>handle</code>	handle of the affected object; null for static methods	<code>methodName</code>	name of the called method
<code>handle</code>	handle of the affected object; null for static methods				
<code>methodName</code>	name of the called method				
Out Parameters	<code>returnValue</code> (optional) encoded return value				
InOutParameters	<code>parameterList</code> a list of encoded parameters for the indicated method. The parameters in <code>parameterList</code> are ordered as they appear in the TTCN-3 method declaration.				
Return Value	The return status of the <code>xtriExternalMethod</code> operation. The return status indicates the local success (TRI_OK) or failure (TRI_Error) of the operation.				
Constraints	<p>This operation is called by the TE when it invokes a method specified in a class which is defined as external in TTCN-3.</p> <p>In the invocation of a <code>xtriExternalMethod</code> operation by the TE all <i>in</i> and <i>inout</i> parameters contain encoded values. No error shall be indicated by the PA in case the value of any <i>out</i> parameter is non-null.</p>				
Effect	<p>The PA shall implement the behaviour for each method of all external classes specified in the TTCN-3 ATS. On invocation of this operation, the PA shall call a method <code>methodName</code> of an external object whose handle is in the <code>handle</code> parameter. It shall access the specified <i>in</i> and <i>inout</i> method parameters in <code>parameterList</code>, pass the values of these parameters to the called method, and compute values for <i>inout</i> and <i>out</i> parameters in <code>parameterList</code>. The operation shall then return encoded values for all <i>inout</i> and <i>out</i> method parameters and the encoded return value. If no return type has been defined for this method in the TTCN-3 ATS, the distinct value <code>null</code> shall be used for the latter.</p> <p>The <code>xtriExternalMethod</code> operation returns TRI_OK if the PA completes the method of the external object successfully, TRI_Error otherwise.</p> <p>Note that whereas most of other TRI operations are considered to be non-blocking, the <code>xtriExternalMethod</code> operation is considered to be <i>blocking</i>. That means that the operation shall not return before the method call has been finished. Methods of external classes have to be implemented carefully as they could cause deadlock of test component execution or even the entire test system implementation.</p>				

Clause 5.6.3.7 `triRaiseException` → `xtriRaiseException`

Signature	<code>void xtriRaiseException(in Value exc)</code>
In Parameters	<code>exc</code> encoded exception to raise
Constraints	This operation can be called by the PA during execution of <code>triExternalFunction</code> , <code>triExternalCreate</code> , <code>triExternalFinally</code> or <code>triExternalMethod</code> .
Effect	The operation raises an exception that can be later processed by the TE in the <code>catch</code> statement. The exception is provided in an encoded form. Decoding is performed in the catch statement.

8.2 Extensions to clause 6 of ETSI ES 201 873-5 Java™ language mapping

Clause 6.5.3.1 Changes to TriPlatformPA

This clause is to be extended.

```
// TriPlatform
// TE -> PA
package org.etsi.ttcn.tri;
public interface xTriPlatformPA {
    ...

    // Ref: TRI-Definition 5.6.3.4
    public TriStatus triExternalCreate(TriClassIdType classId,
        TciParameterList parameterList, TriObjHandleWrapper handle);

    // Ref: TRI-Definition 5.6.3.6
    public TriStatus xtriExternalMethod(Object handle, String methodName,
        TciParameterList parameterList, TciParameter returnValue);
}
```

Clause 6.5.3.1 Changes to TriPlatformPA

This clause is to be extended.

```
// TriPlatform
// PA -> TE
package org.etsi.ttcn.tri;
public interface xTriPlatformTE {
    ...

    // Ref: TRI-Definition 5.6.3.7
    public void triRaiseException(Value exc);
}
```

8.3 Extensions to clause 7 of ETSI ES 201 873-5 ANSI C language mapping

Clause 7.2.4 TRI operation mapping

This clause is to be extended.

IDL Representation	ANSI C Representation
...	
TriStatusType xtriExternalCreate (in TriClassIdType classId, inout TciParameterListType parameterList, out TriObjHandleType createdObject)	TriStatus xtriExternalCreate (const TriClassId* classId, TciParameterList* parameterList, TriObjectHandle* handle)
TriStatusType xtriExternalMethod(in TriObjHandleType handle, in String methodName, inout TciParameterListType parameterList, out TciParameterType returnValue)	TriStatus xtriExternalFunction (TriClassId handle, char* methodName, TciParameterList* parameterList, TciParameter* returnValue)
void xtriRaiseException(in Value exc)	void xtriRaiseException(const Value* exc)

8.4 Extensions to clause 8 of ETSI ES 201 873-5 C++ language mapping

Clause 8.6.3 TriPlatformPA

This clause is to be extended.

```
class xTriPlatformPA {
public:
    ...

    //For each constructor on an external class specified in the TTCN-3 ATS implement the behaviour.
    virtual TriStatus xtriExternalCreate (const TriClassId *classId, TciParameterList
    *parameterList, TriObjectHandle * handle)=0;
    //For each method on an external class specified in the TTCN-3 ATS implement the behaviour.
    virtual TriStatus xtriExternalMethod (TriObjectHandle handle, const Tstring & methodName,
    TciParameterList *parameterList, TciParameter *returnValue)=0;
}

```

Clause 8.6.4 TriPlatformTE

This clause is to be extended.

```
class xTriPlatformTE {
public:
    ...

    //Raises an exception during execution of external code in PA
    virtual void xtriRaiseException (const TciValue *exc)=0;
}

```

8.5 Extensions to clause 9 of ETSI ES 201 873-5 C# language mapping

Clause 9.5.2.3 TriPlatformPA

This clause is to be extended.

```
public interface IXTriPlatformPA {
    ...

    // Miscellaneous operations
    // Ref: TRI-Definition clause 5.6.3.4
    TriStatus XTriExternalCreate(ITriClassId classId,
    ITciParameterList parameterList, out object handle);

    // Ref: TRI-Definition clause 5.6.3.6
    TriStatus XTriExternalMethod(object handle, string methodName,
    ITciParameterList parameterList, ITciParameter returnValue);
}

```

Clause 9.5.2.4 TriPlatformTE

This clause is to be extended.

```
public interface IXTriPlatformTE {
    ...

    // Ref: TRI Definition clause 5.6.3.7
    void XTriRaiseException(ITciValue exc);
}

```

Annex A (normative): BNF and static semantics

A.1 Extensions to TTCN-3 terminals

The list of reserved terminals which are keywords in table A.3 in ETSI ES 201 873-1 [1] needs to be extended with **class**, **finally**, **object** and **this**. The extension of table A.3 in ETSI ES 201 873-1 [1], clause A.1.5.0 is shown below.

action	fail	noblock	select
activate	false	none	self
address	finally	not	send
alive	float	not4b	sender
all	for	nowait	set
alt	friend	null	setverdict
altstep	from		signature
and	function	object	start
and4b		octetstring	stop
any	getverdict	of	subset
anytype	getcall	omit	superset
	getreply	on	system
bitstring	goto	optional	
boolean	group	or	template
break		or4b	testcase
	halt	out	this
case	hexstring	override	timeout
call			timer
catch	if	param	to
char	ifpresent	pass	trigger
charstring	import	pattern	true
check	in	permutation	type
class	inconc	port	
clear	infinity	present	union
complement	inout	private	universal
component	integer	procedure	unmap
connect	interleave	public	
const			value
continue	kill	raise	valueof
control	killed	read	var
create		receive	variant
	label	record	verdicttype
deactivate	language		
decmatch	length	recursive	while
default	log	rem	with
disconnect		repeat	
display	map	reply	xor
do	match	return	xor4b
done	message	running	
	mixed	runs	
else	mod		
encode	modifies		
enumerated	module		
error	modulepar		
except	mtc		
exception			
execute			
extends			
extension			
external			

A.2 Modified TTCN-3 syntax BNF productions

This clause includes all BNF productions that are modifications of BNF rules defined in the TTCN-3 core language document ETSI ES 201 873-1 [1]. When using this package the BNF rules below replace the corresponding BNF rules in the TTCN-3 core language document. The rule numbers define the correspondence of BNF rules.

BNF changes in clause A.1.6.1.1 Type definitions

```
12. StructuredTypeDef ::= RecordDef |
                        UnionDef |
                        SetDef |
                        RecordOfDef |
                        SetOfDef |
                        EnumDef |
                        PortDef |
                        ComponentDef |
                        ClassDef
```

BNF changes in clause A.1.6.1.4 Function definitions

```
158. FunctionDef ::= FunctionKeyword [ DeterministicModifier | ControlModifier ]
                   IdentifierOrControl "(" [ FunctionFormalParList ] ")"
                   [ RunsOnSpec ] [ MtcSpec ] [ SystemSpec ] [ ReturnType ] [ ExceptionSpec ]
                   StatementBlock
169. StatementBlock ::= BasicStatementBlock [ CatchBlocks ] [ FinallyBlock ]
176. FunctionRef ::= [ ( Identifier | ObjectInstance ) Dot ]
                   ( Identifier | PreDefFunctionIdentifier )
```

BNF changes in clause A.1.6.1.6 Testcase definitions

```
185. TestcaseDef ::= TestcaseKeyword Identifier "(" [ TemplateOrValueFormalParList ] ")" ConfigSpec
                   StatementBlock
```

BNF changes in clause A.1.6.1.7 Altstep definitions

```
192. AltstepDef ::= AltstepKeyword [ ControlModifier ] [ InterleaveKeyword ]
                   Identifier "(" [ FunctionFormalParList ] ")"
                   [ RunsOnSpec ] [ MtcSpec ] [ SystemSpec ] [ ExceptionSpec ]
                   "{ " AltstepLocalDefList AltGuardList " }" [ CatchBlocks ] [ FinallyBlock ]
```

BNF changes in clause A.1.6.1.10 External function definitions

```
235. ExtFunctionDef ::= ExtKeyword FunctionKeyword [ DeterministicModifier | ControlModifier ]
                       Identifier "(" [ FunctionFormalParList ] ")"
                       [ ReturnType ] [ ExceptionSpec ]
```

BNF changes in clause A.1.6.3.1 Variable instantiation

```
261. ValueRef ::= [ ThisOp Dot ] Identifier [ ExtendedFieldReference ]
```

BNF changes in clause A.1.6.4.1 Component Operations

```
267. CreateOp ::= Type Dot CreateKeyword [ ActualParList ]
                 [ AliveKeyword ]
                 ExternalKeyword ActualParList
```

BNF changes in clause A.1.6. 5 Type

```
400. PredefinedType ::= BitStringKeyword |
                       BooleanKeyword |
                       CharStringKeyword |
                       UniversalCharString |
                       IntegerKeyword |
                       OctetStringKeyword |
                       HexStringKeyword |
                       VerdictTypeKeyword |
                       FloatKeyword |
                       AddressKeyword |
                       DefaultKeyword |
                       AnyTypeKeyword |
                       TimerKeyword |
                       ObjectKeyword
```

BNF changes in clause A.1.6.6 Value

```
433. ReferencedValue ::= ( ( ExtendedIdentifier | ThisOp ) [ExtendedFieldReference] )
    | ReferencedEnumValue
```

BNF changes in clause A.1.6.8.2 Behaviour statements

```
479. BehaviourStatements ::= TestcaseInstance |
    FunctionInstance |
    ReturnStatement |
    AltConstruct |
    InterleavedConstruct |
    LabelStatement |
    GotoStatement |
    RepeatStatement |
    DeactivateStatement |
    AltstepInstance |
    ActivateOp |
    BreakStatement |
    ContinueStatement |
    RaiseExceptionStatement
```

BNF changes in A.1.6.8.3 Basic statements

```
548. RelOp ::= "<" | ">" | ">=" | "<=" | OfKeyword
```

A.3 Additional TTCN-3 syntax BNF productions

This clause includes all additional BNF productions that needed to define the syntax introduced by this package. All rules start with the digits "0330".

Additional BNF rules related to clause A.1.6.1.1 Type definitions

```
033001. ClassDef ::= [ ExtKeyword ] ClassKeyword [ FinalModifier | AbstractModifier ]
    Identifier [ ExtendsKeyword ClassType ] [ RunsOnSpec ] [ MtcSpec ] [ SystemSpec
]
    "{" ClassMemberList "}"
    [ FinallyKeyword BasicStatementBlock ]
033002. ClassKeyword ::= "class"
033003. ThisOp ::= "this"
033004. SuperOp ::= "super"
033005. FinalModifier ::= "@final"
033006. AbstractModifier ::= "@abstract"
033007. FinallyKeyword ::= "finally"
033008. ObjectKeyword ::= "object"
033008a. ClassType ::= ReferencedType | ObjectKeyword
/* STATIC SEMANTICS - ReferencedType shall evaluate to a class. */
033009. ClassMemberList ::= { ClassMember [ WithStatement ] [ SemiColon ] }
033010. ClassMember ::= [ MemberVisibility ]
    ( VarInstance |
    TimerInstance |
    ClassConstDef |
    ClassTemplateDef |
    ClassFunctionDef |
    ConstructorDef |
    ClassDef )
033011. MemberVisibility ::= "public" | "private"
033012. ClassFunctionDef ::= [ ExtKeyword ] FunctionKeyword
    [ FinalModifier | AbstractModifier ] [ DeterministicModifier ]
    Identifier "(" [ FunctionFormalParList ] ")" [ ReturnType ]
    [ StatementBlock ]
033013. ConstructorDef ::= CreateKeyword
    "(" FunctionFormalParList )"
    [ ExternalKeyword "(" FunctionFormalParList )" ]
    [ ":" ReferencedType ActualParList ]
    [ StatementBlock ]
/* STATIC SEMANTICS - ReferencedType shall evaluate to a class. */
033013a. ClassConstDef ::= ConstKeyword Type ClassConstList
033013a1. ClassConstList ::= SingleClassConstDef {"," SingleClassConstDef}
033013a2. SingleClassConstDef ::= Identifier [ArrayDef] [ AssignmentChar ConstantExpression ]
```

```
033013b. ClassTemplateDef ::= TemplateKeyword [TemplateRestriction]
                             [FuzzyModifier [DeterministicModifier]]
                             BaseTemplate [DerivedDef] [ AssignmentChar BaseTemplateBody ]
```

Additional BNF rules related to clause A.1.6.1.4 Function definitions

```
033014. BasicStatementBlock ::= "{" [ FunctionDefList ] [ FunctionStatementList ]}"
033015. CatchBlocks ::= CatchBlock { CatchBlock }
033016. CatchBlock ::= CatchOpKeyword "(" Type Identifier ")" BasicStatementBlock
033017. FinallyBlock ::= FinallyKeyword BasicStatementBlock
033018. ObjectInstance ::= ( ThisOp | ValueRef | FunctionInstance ) [ ExtendedFieldReference ]
```

Additional BNF rules related to clause A.1.6.8.2 Behaviour statements

```
033019. RaiseExceptionStatement ::= RaiseKeyword TemplateInstance
/* STATIC SEMANTICS - The TemplateInstance shall evaluate to an explicit value. */
```

Annex B (normative): Standard Collections

B.1 The TTCN3_standard_collections module

B.1.0 General

The classes and external functions defined in this module provide users with the following commonly used data structures.

```

module TTCN3_standard_collections {

function instanceEqual(object element1, object element2) return boolean {
    return element1 == element2
}

public external function createLinkedList(in equalsFunctionType equalsFunction := instanceEqual)
return LinkedList;
public external function createQueue(in equalsFunctionType equalsFunction := instanceEqual)
return Queue;
public external function createPriorityQueue(in comparatorFunctionType comparatorFunction)
return PriorityQueue;
public external function createStack(in equalsFunctionType equalsFunction := instanceEqual)
return Stack;
public external function createRingBuffer(in integer maxSize) return RingBuffer;
public external function createHashMap(in hashFunctionType hashFunction,
                                     in equalsFunctionType equalsFunction) return HashMap;

public external function createSet(in equalsFunctionType equalsFunction := instanceEqual)
return Set;

public type class @abstract Exception {
}
type class @abstract Iterator {
    function @abstract hasNext() return boolean;
    function @abstract next() return object;
}
type class @abstract Collection {
    function size() return integer;
    function contains(object element) exception Exception return boolean;
    function @abstract iterator() return Iterator;
}
type class @abstract List extends Collection {
    public function @abstract add(object element) exception Exception;
    public function @abstract remove(object element) exception Exception return boolean;
    public function @abstract get(integer index) exception Exception return object;
}
public type class @abstract LinkedList extends List {
    public function @abstract getFirst() exception Exception return object;
    public function @abstract getLast() exception Exception return object;
    public function @abstract removeFirst() exception Exception return object;
    public function @abstract removeLast() exception Exception return object;
    public function @abstract addFirst(object element) exception Exception;
    public function @abstract addLast(object element) exception Exception;
}
public type class @abstract Queue extends Collection {
    public function @abstract add(object element) exception Exception;
    public function @abstract remove() exception Exception return object;
}
public type function comparatorFunctionType(in object element1, in object element2) exception
Exception return integer;
public type class @abstract PriorityQueue extends Queue {
}
public type class @abstract Stack extends Collection {
    public function @abstract push(object element) exception Exception;
    public function @abstract pop() exception Exception return object;
}

public type class @abstract RingBuffer extends Collection {
    public function @abstract put(object element) exception Exception;
    public function @abstract get() exception Exception return object;
    public function @abstract capacity() return integer;
}

```

```

}

public type function hashFunctionType(in object element) exception Exception return integer;
public type function equalsFunctionType(in object element1, in object element2) exception Exception
return boolean;

public type class @abstract HashMap {
  public function @abstract put(object keyElement, object valueElement) exception Exception;
  public function @abstract get(object keyElement) exception Exception return object;
  public function @abstract containsKey(object keyElement) exception Exception return boolean;
  public function @abstract remove(object keyElement) exception Exception return object;
  public function @abstract keySet() return Set;
  public function @abstract values() return List;
  public function @abstract size() return integer;
}
public type class @abstract Set extends Collection {
  public function @abstract add(object element) exception Exception return boolean;
  public function @abstract remove(object element) exception Exception;
}
}

```

B.1.1 The Collection class

The abstract [Collection](#) class represents a data structure that is a collection of elements. It is used as a base class of more specific collection data structures like lists and sets.

External function and class methods:

- `size`
Returns the number of elements stored in the LinkedList.
- `contains`
Returns the value `true` if the given element is contained at least once in the collection.
- `iterator`
Returns an Iterator object for iterating over the elements of the collection.

B.1.2 The List class

The abstract [List](#) class represents a list of elements where each contained element has an index (starting from 0).

External function and class methods:

- `add`
Adds the given element to the list.
- `remove`
Tries to remove one instance of the provided element from the List.
Returns **true** if an element was removed, **false** if no elements were removed.
Please note, that a List might contain the same element several times, in which case only one instance will be removed.
- `get`
Gets the element at the given index from the list, if the index is in the range (0 .. size()-1).

B.1.3 The LinkedList class

The abstract [LinkedList](#) class represents a double linked data structure for storing objects.

A new Instance can be created via the external function **createLinkedList**. It is derived from the abstract List class.

External function and class methods:

- `createLinkedList`
Factory function for creating a new LinkedList instance.
- `getFirst`
Returns the first element of the LinkedList if it is not empty.
Raises an exception if the LinkedList is empty.

- `getLast`
Returns the last element of the `LinkedList` if it is not empty.
Raises an exception if the `LinkedList` is empty.
- `removeFirst`
Removes and returns the first element of the `LinkedList` if it is not empty.
Raises an exception if the `LinkedList` is empty.
- `removeLast`
Removes and returns the last element of the `LinkedList` if it is not empty.
Raises an exception if the `LinkedList` is empty.
- `addFirst`
Adds a new element as the first element of the `LinkedList` if this is possible.
Raises an exception in case of error, for example: running out of memory.
- `addLast`
Adds a new element as the last element of the `LinkedList` if this is possible.
Raises an exception in case of error, for example: running out of memory.
- `iterator`
Returns an iterator over the elements of this `LinkedList`.
The elements are iterated from first to last.
- `size`
Returns the number of elements stored in the `LinkedList`.

B.1.4 The Queue class

The abstract [Queue](#) class represents a queue data structure for storing objects. This data structure uses a First In First Out semantics, meaning that the element added first will also be the element removed first. It is derived from the abstract class `Collection`.

A new Instance can be created via the external function **`createQueue`**.

External function and class methods:

- `createQueue`
Factory function for creating a new `Queue` instance.
- `add`
Adds an element to the end `Queue` if this is possible.
Raises an exception in case of error, for example: running out of memory.
- `remove`
Removes and returns the first element of the `Queue` if it is not empty.
Raises an exception if the `Queue` is empty.
- `size`
Returns the number of elements stored in the `Queue`.

B.1.5 The PriorityQueue class

The abstract [PriorityQueue](#) class represents a priority queue data structure for storing objects. This data structure stores its elements ordered according to the comparator function. This data structure does not allow null elements.

A new Instance can be created via the external function **`createPriorityQueue`**. It is derived from the class `Queue`.

External function and class methods:

- `createPriorityQueue`
Factory function for creating a new `PriorityQueue` instance.
- `comparatorFunctionType`
Used to compare the 2 provided elements for their ordering.
Returns a negative integer if the element1 is less than element2.

Returns 0 if the element1 is equivalent to element2.

Return a positive integer if element1 is greater than element2.

Functions of this type can also raise an exception, for example if the object received as one of their actual parameters is not of the expected class.

- `add`
Adds an element to the `PriorityQueue` if this is possible. The element will be added before all elements that are greater than the element and after all elements that are smaller than or equal to the element. Thereby it is ensured that always the smallest element first added to the queue is at the head of the queue.
Raises an exception in case of error, for example: running out of memory or adding a null object.
- `remove`
Removes and returns the head element of the `PriorityQueue` if it is not empty. The head element has the lowest priority among the elements of the `PriorityQueue`.
Raises an exception if the `PriorityQueue` is empty.
- `size`
Returns the number of elements stored in the `PriorityQueue`.

B.1.6 The Stack class

The abstract [Stack](#) class represents a stack data structure for storing objects. This data structure uses a Last In First Out semantics, meaning that the element added last will also be the element removed first.

A new Instance can be created via the external function **createStack**.

External function and class methods:

- `createStack`
Factory function for creating a new `Stack` instance.
- `push`
Pushes an element onto the `Stack` if this is possible.
Raises an exception in case of error, for example: running out of memory.
- `pop`
Removes and returns the element inserted last from the `Stack` if it is not empty.
Raises an exception if the `Stack` is empty.
- `size`
Returns the number of elements stored in the `Stack`.

B.1.7 The RingBuffer class

The abstract [RingBuffer](#) class represents a ringbuffer data structure for storing objects. This data structure uses a First In First Out semantics, with a fixed size limit. This means that the element added first will also be the element removed first. An instance of this collection can only accept elements to the maximum amount it is created for.

A new Instance can be created via the external function **createRingBuffer**.

External function and class methods:

- `createRingBuffer`
Factory function for creating a new `RingBuffer` instance, with the provided maximum size.
- `put`
Adds an element to the end of the `RingBuffer` if this is possible.
Raises an exception in case of error, for example: reaching the maximum allowed size of the buffer.
- `get`
Removes and returns the first element of the `RingBuffer` if it is not empty.
Raises an exception if the `RingBuffer` is empty.
- `size`
Returns the number of elements stored in the `RingBuffer`.

- `capacity`
Returns the maximum capacity of the RingBuffer.

B.1.8 The HashMap class

The abstract [HashMap](#) class represents a hashmap data structure for storing key-value pairs of objects. This collection can be indexed with the `keyElement` part of the pair, to receive the `valueElement` of the pair.

Please note that each key has to be unique according to the given **equalsFunction**.

A new Instance can be created via the external function **createHashMap**.

The hash value of the `keyElement` object can be calculated using the provided **hashFunctionType** function and the equality of two given `keyElements` can be determined using the provided **equalsFunctionType** function.

External function and class methods:

- `createHashMap`
Factory function for creating a new HashMap instance, that will use the provided `hashFunction` for calculating the hash values of the key element objects and an `equalsFunction` for determining the equality of keys. The two functions need to fulfil the property that for all pairs of objects `o1`, `o2`, if `equalsFunction(o1,o2)` is true then also `hashFunction(o1)==hashFunction(o2)` is true.
- `hashFunctionType`
A behaviour type allowing the user of the collection to provide their implementation for calculating the hash value of their key element objects.
Functions of this type will be called with a key element object as their only parameter and shall return an integer value that represents the hash value of the object.
Functions of this type can also raise an exception, for example if the object received as their actual parameter is not of the expected class.
- `equalsFunctionType`
A behaviour type allowing the user of the collection to provide their implementation with an equality relation between key objects insofar that different object instances of the same content can be seen as equal which allows to ensure the uniqueness property for the keys as there can be no two different key instances `k1`, `k2` where `equalsFunction(k1.k2)` is true.
- `put`
Adds a new `keyElement` – `valueElement` pair to the HashMap.
If the HashMap already contains a pair with the same `keyElement`, the old pair is removed before inserting the new pair.
Raises an exception in case of error, for example: running out of memory.
- `get`
Returns the `valueElement` part of a `keyElement` – `valueElement` pair in the HashMap, if such a pair with the provided `keyElement` object exists in the HashMap.
Raises an exception if the HashMap has no `keyElement` – `valueElement` pair with the provided `keyElement`.
- `containsKey`
Returns **true** if the HashMap contains a `keyElement` – `valueElement` pair with the provided `keyElement`, **false** otherwise.
Raises an exception in case of error, for example the `hashFunction` raised an exception.
- `remove`
Removes a `keyElement` – `valueElement` and returns the `valueElement` part of a `keyElement` – `valueElement` pair in the HashMap, if such a pair with the provided `keyElement` object exists in the HashMap.
Raises an exception in case of error, for example the `hashFunction` raised an exception.
- `keyset`
Returns a Set object containing a set of the `keyElements` of all the `keyElement` – `valueElement` pairs in the HashMap.
- `values`
Returns a List object containing the `valueElement` objects of all the `keyElement` – `valueElement` pairs in the HashMap.

- `size`
Returns the number of pairs stored in the HashMap.

B.1.9 The Set class

The abstract [Set](#) class represents a set data structure for storing objects. This data structure is unordered and contains unique elements.

A new Instance can be created via the external function `createSet`.

External function and class methods:

- `createSet`
Factory function for creating a new Set instance. It may be passed an `equalsFunction` to determine equality and ensure uniqueness of the contained set elements. Per default, instance equality is used.
- `add`
Adds an element to the Set if this is possible.
Returns true if the element could be added, returns false if the element was already present in the set and so was not added (to ensure uniqueness).
Raises an exception in case of error, for example: running out of memory.
- `remove`
Removes the provided element from the Set if it is present in the set.
Returns true if the element was located in the Set, false otherwise.
Subclasses might raise an exception.
- `contains`
Returns **true** if the Set contains the element, **false** otherwise.
Subclasses might raise an exception.
- `iterator`
Returns an iterator over the elements of this Set.
The elements are not iterated in any particular order.
- `size`
Returns the number of elements stored in the Queue.

B.1.10 The Exception class

The abstract [Exception](#) class represents a generic exception that can be raised by standard collections.

Please note, that later the list of raised exception can be updated with more specific exceptions.

B.1.11 The Iterator class

The abstract [Iterator](#) class represents an iterator over a collection. An instance of the Iterator class allows to iterate over the elements of a collection.

Class methods:

- `hasNext`
Returns true if the iterated collection still has elements not yet visited by the iterator.
- `next`
Returns the next element in the collection and steps the iterator for the upcoming collection.
Raises an exception if the collection has no more elements not yet visited.

History

Document history		
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