ETSI The Standards People

TTCN-3 Language Extensions Object-Oriented Features

(ETSI ES 203 790)

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For: **TTCN-3 Webinar**

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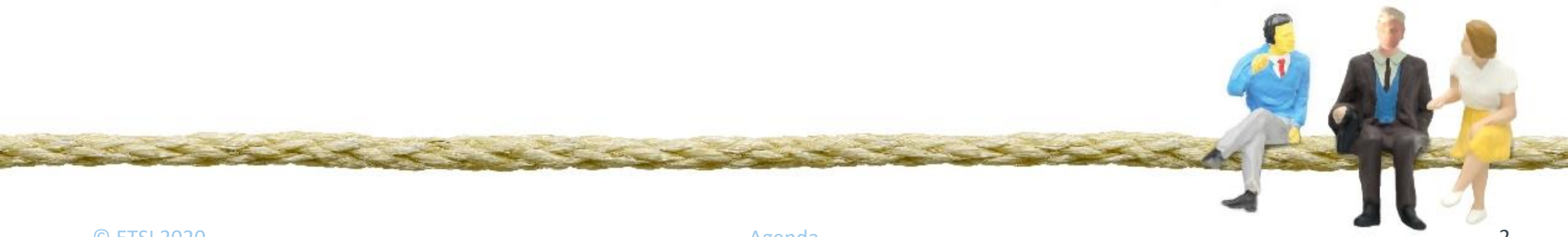
Agenda

- Motivation and ideas
  - Added value of OO for TTCN-3
  - General introduction on OO
  - Differences against OO programming languages
- Details on TTCN-3 OO languages features
  - Definition of class types using methods and fields
  - Exception handling



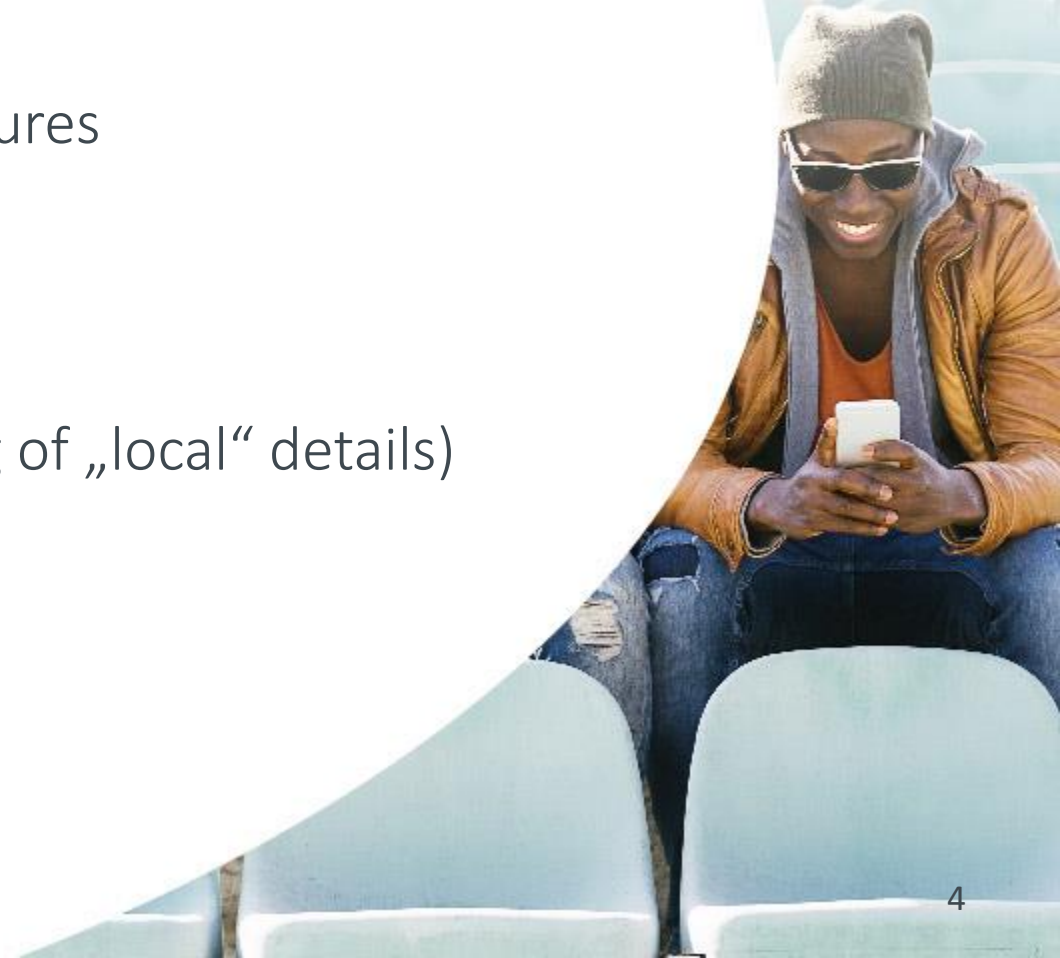
Object Orientation:

Motivation and ideas

Object Orientation: Motivation and added value

- Heighten appeal of TTCN-3 to users used to object-oriented programming
- Use advantages of object-oriented modelling
- Reduce TTCN-3 emulation of object-oriented features
- Allow simple access to external objects

- Handling of larger and more complex tests (hiding of „local“ details)
  - Data and functions operating on it are kept together
  - Providing support for fine-grainded information hiding
  - More attractive for OO software developers



General introduction to OO programming

- Concept of objects which can contain data (fields: attributes or properties) and behaviour (procedures: methods)
- Object‘s procedures can access and often modify the data fields of the objects („this“ or „self“)
- OO programs are designed out of objects that interact with each other
- Most OOP languages are class-based, i.e. objects are instances of classes (their „types“)

Source: Wikipedia

Differences against common OO programming languages

- Methods can be overridden, but *not* overloaded. Private members can *not* be overridden.
  - ⇒ Less confusion
- Fields can *not* be public
  - ⇒ Local data responsibility
- No multiple or interface inheritance (so far)
  - ⇒ Avoid usual problems with multiple inheritance and name-clashes
- No static members
  - ⇒ TTCN-3 does not allow global variables
  - ⇒ Instead of static functions, global functions can be used

Differences against common OO programming languages – New Features

- Objects are *owned* by the component creating them. Methods can only be called by behaviour running on the owning component.
  - ⇒ No data racing conditions
- **Classes can have runs on, mtc and system clauses**, restricting test system context and usage of classes
  - ⇒ No repetition of clauses for methods
  - ⇒ Statically checkable safe access to test system environment
- External classes
  - ⇒ Simple access to external objects
- Implicit constructor
  - ⇒ Less boilerplate code

Definition of class types

Simple class definition

- A *class* defines a new **TTCN-3 type**, containing one or more members:
  - Fields: `var`, `const`, `template`, `port`, `timer`
  - Methods: `function`, constructor (`create`)

```
type class Person {
    //fields
    var charstring v_name;

    //methods
    function f_nameLog() {log(v_name);…};
    create() {this.v_name := "noname";}
    }
```

reference a member of own object (class)

Objects of classes (1)

```
type class Person {
    var charstring v_name;
    function f_nameLog() {log(v_name);…};
    create() {this.v_name := "noname";}
    }
```

- An ***object*** is an instance (i.e. a *value*) of a *class*,
  - comprising a data instance of each field of the class,
  - created after invocation of the constructor of the class
  - can be created in a behavior running on a TTCN-3 component (the *owner* of the object)

Objects of classes (2)

```
type class Person {
    var charstring v_name;
    function f_nameLog() {log(v_name);…};
    }
```

- Implicit constructor *(not required to be specified)*:

```
create (charstring v_name) {this.v_name := v_name;}
```

- An object reference is contained in a variable of a class type.
- Creation and use of the object

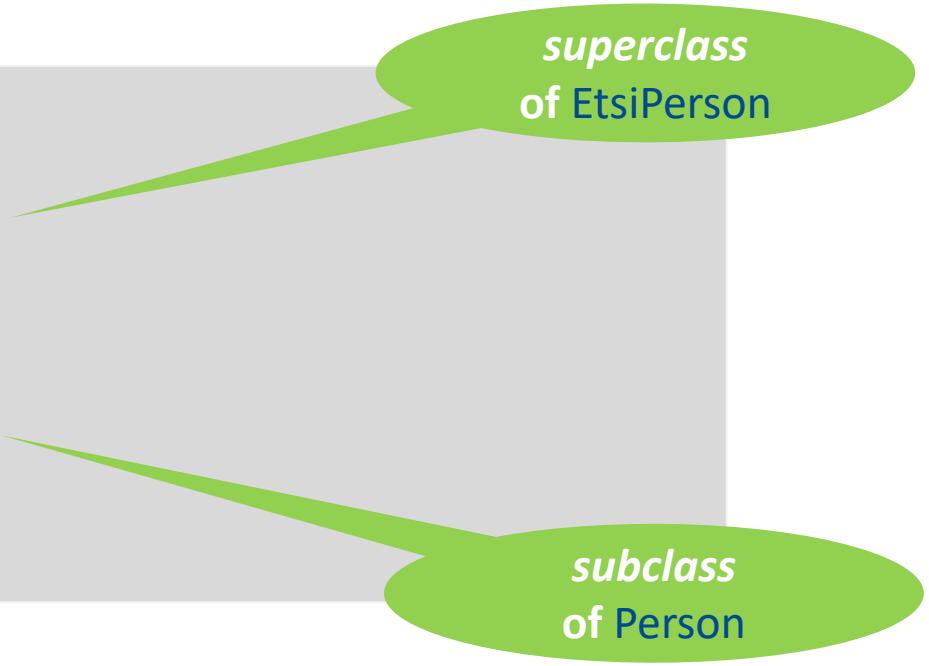
```
var Person v_chair := Person.create("Anthony");
v_chair.f_nameLog()
```

output is: Anthony

Inheritance of classes

```
type class Person {
    var charstring v_name;
    function f_nameLog() {log(v_name);…};
    }

type class EtsiPerson extends Person {
    var charstring v_position;
    }
```



- A class definition inherits all declarations from its super class

Visibility of members

- Fields are *private* or *protected* (default is protected)
  - and can not be overwritten

```
type class Person {
    var charstring v_name;
    function f_nameLog(charstring p_c) {log(v_name);…};
    }
type class EtsiPerson extends Person {
    var charstring v_position;
    public function f_nameLog(charstring p_c) {log(v_name & p_c);…};
    }
```

field is „protected“!

field is „protected“!

- *private* and *protected* members can not be accessed outside their class

```
var EtsiPerson v_chair := EtsiPerson.create("Anthony", "Chair");
v_chair.f_nameLog("56");
log(v_chair.v_name);
```

output is: Anthony56

ERROR: no access to fields

Visibility of members (cont.)

- Methods are *private*, *protected* or *public* (default is protected)

```
type class Person {
    var charstring v_name := "Anthony";
    function f_nameLog(charstring p_c) {log(v_name);…};
    }

type class NewPerson extends Person {
    function f_nameLog(charstring p_c) {log(v_name & p_c);…};
    public function f_superLog() {super.f_nameLog("Alex");};
    }
```

method is *„protected“!*

- *Public* member functions can only be overwritten by *public* member functions and can be called from any behavior on the object's owner component

```
var EtsiPerson v_chair := NewPerson.create;
v_chair.f_superLog();
```

output is: Anthony

Component type restrictions

- *runs on*, *system*, *mtc* clauses restrict the component context that can create objects of that class and call methods of the class (if missing, inherited from superclass) and shall be compatible with superclass clauses
- *function* members inherit restrictions from the containing class (no own *runs on*, *system*, *mts* clauses)

```
type component MyComponent {
    port myport MyPortType;…
    }

type class Person runs on MyComponent system MySUT mtc MyTester {
    var charstring v_name;
    function f_nameLog() {myport.receive;…};
    }
```

Object reference and class casting

- To access an object *instance* an object *reference* is needed.
- The object is not copied when used as an actual parameter or assigned to a variable (only the reference).
  - Multiple variables can contain a reference to the same object simultaneously.
- Objects cannot be shared by multiple components.
- Object references can be cast to another class
  - New class shall be within the set of (direct or indirect) superclass or subclass

```
var Person v_person := EtsiPerson.create("Anthony");
var EtsiPerson v_etsichair := v_person => EtsiPerson;
```

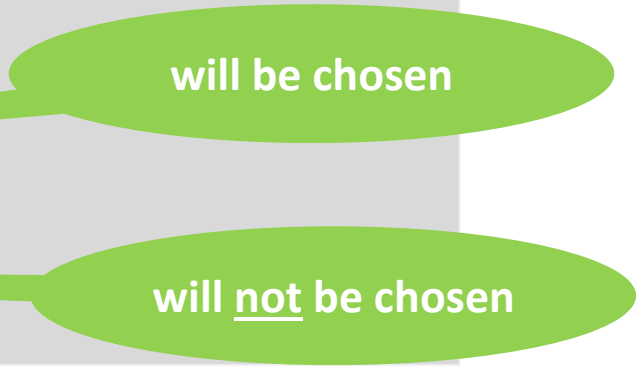
two references for the one object

Class type discrimination

```
type class MyClass {…}
type class MyClassB extends MyClass {…}
```

- *of*-operator checks if most specific class of the ***object*** (*left-hand* side) is equal or subclass derived from the ***class type*** (*right-hand* side)
- *select class*-statement discriminates the class of an object (allows superclasses and subclasses of the object)

```
testcase TC_1() {…
    var MyClass v_a := MyClass.create;
    var MyClass v_b := MyClassB.create;
    if (v_a of MyClass) {…};
    select class (v_b) {
        case(MyClassB) {…}
        case(MyClassA) {…}
    }}
```



Outlook – Additional Features

- External classes and methods
- Abstract classes and methods, final classes

Already in the last standard version (2020):

- Nested classes
- Generic classes and methods
- Mixed classes (External classes with internal additional behaviour/state)

Next standard version (2021):

- Interfaces and multiple interface inheritance (similar to Java)
- Properties (similar to C#)

Additional Ideas Welcome!

Application example

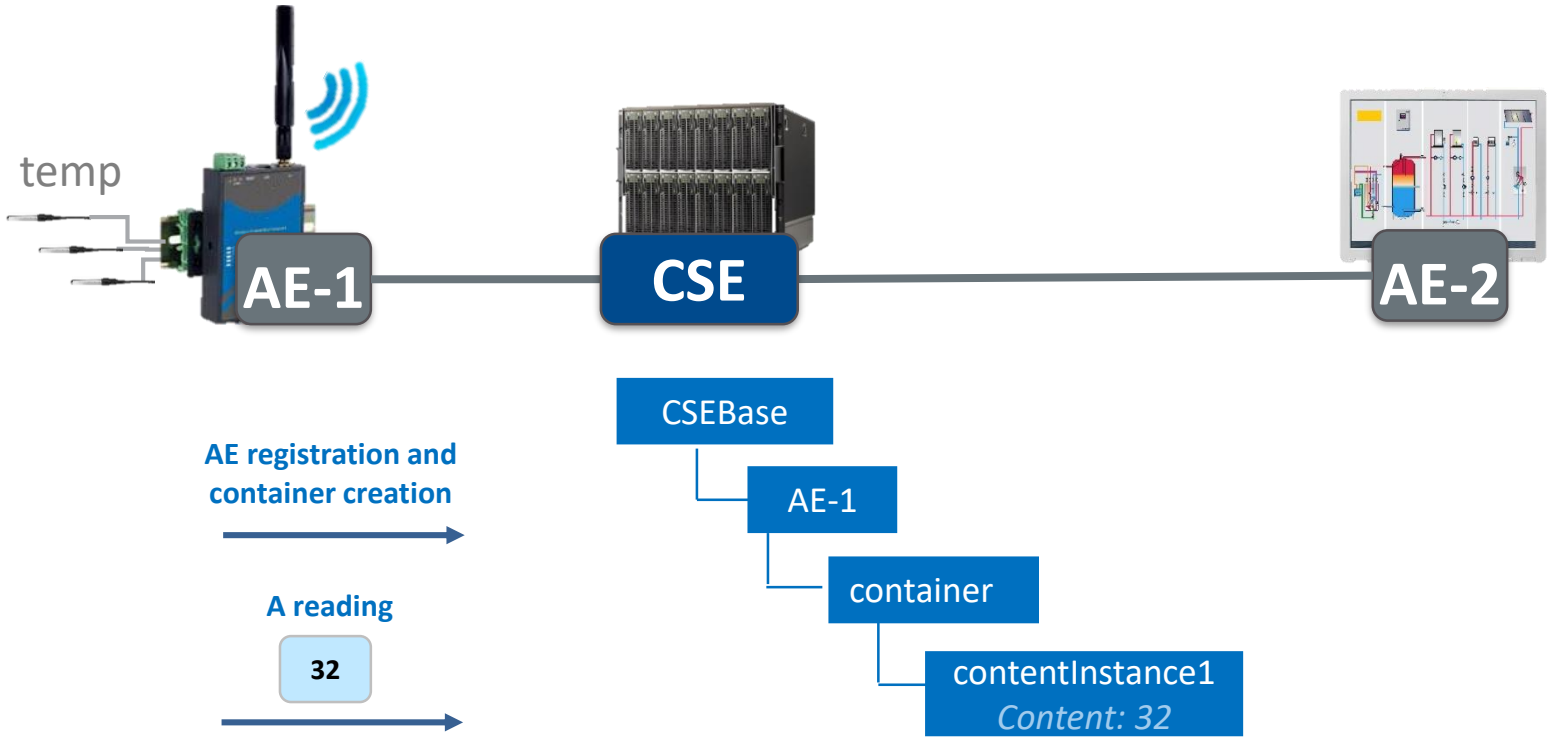
Application example

- Application background:
  - oneM2M common service/application elements (CSE/AE)
  - sample use cases
- Specification of semantic descriptor (TTCN-3)
  - class type instead of record type
  - sample application (extended class)

Application background

- oneM2M common service/application elements (CSE/AE)
- Addition of semantics annotations:
  to discover dedicated AE‘s (e.g. sensors), based on their location (e.g. area) or kind (e.g. temperature) etc.
- Possible scenarios:
  - creation of AE representation at CSE (e.g. container, contentInstance),
    e.g. temperature sensors
  - addition of semantic descriptors to AE representation, by other AE (e.g. dashboard)
  - semantic discovery, requested by other AE (e.g. mobile handheld)

Semantic annotation



AE: Application Entity
CSE: Common Services Entity

Source: oneM2M.org

SemanticDescriptor in oneM2M

```
type record SemanticDescriptor {
 ResourceName resourceName,
 ResourceType resourceType,
 XSD.ID resourceID,
 NhURI parentID,
 Timestamp creationTime,
 Timestamp lastModifiedTime,
 Labels labels optional,
 AcpType accessControlPolicyIDs optional,
 Timestamp expirationTime,
  …
}
```

- Currently (for historical reasons) using **record type** for *SemanticDescriptor*
- For the sake of simplicity the example leaves out some fields
- Note: related behavior (such as field set/get functions) is defined separately

SemanticDescriptor using `class` type

- Introduction of **class type** for *SemanticDescriptor*
- Additional class fields can be provided if using class **inheritance**

```
type class SemanticDescriptor {
 var ResourceName resourceName;
 var ResourceType resourceType;
 var XSD.ID resourceID;
 var NhURI parentID;
 var Timestamp creationTime;
 var Timestamp lastModifiedTime;
 var Labels labels;
 var AcpType accessControlPolicyIDs;
 var Timestamp expirationTime;
  …
}
```

OO application example

- Extension of *SemanticDescriptor* for simplified handling of context-related details

- Example:
  TemperatureSemanticDescriptor extends *SemanticDescriptor*
  - Add context information, e.g. temperature types (C/F), usage (indoor/outdoor), manufacture information (country, price etc.), temperature ranges (-30…40), defaults/standards
  - Add related functionality (translation formula, exchange rates): `f_compatibility, f_translate`

OO types - example

```
type class TemperatureSemanticDescriptor extends SemanticDescriptor {
      var charstring MeasurementUnit;
      var charstring Usage;
      var integer LowerLimit;
      var integer UpperLimit;
      function f_compatibility(…) return boolean;
      function f_translate(…);
      create (charstring p_mu, charstring p_u, integer p_ll, integer p_ul):
          SemanticDescriptor(…)
         {this.MeasurementUnit:= p_mu, this.Usage:= p_u,
         this.LowerLimit:= p_ll, this.UpperLimit:= p_ul,};}
```

analyse compatibility (e.g. value range)

between different measurement units

```
var TemperatureSemanticDescriptor v_tSensorEU :=
      TemperatureSemanticDescriptor.create("celsius", "outdoor", -30, 40);
var TemperatureSemanticDescriptor v_tSensorUS :=
      TemperatureSemanticDescriptor.create("fahrenheit", "indoor", 32, 104);
```

ONLY temperature related fields

Exception handling

Exception handling

- Exception type lists:
  functions, external functions, altsteps
- *raise* exception statements
- “catch” and “finally” clauses:
  statement blocks, altsteps and testcase

raise Exception statement

- Causes **leaving** of: statement block, loop, alt, interleave
  - within the encompassing function/altstep/testcase

  (1) Execution **continues** in the *catch-block*
  - If encompassing function/altstep/testcase has *catch-block* (with same type, or can be cast)

  (2) Execution **leaves** function/altstep/testcase
  - If NO *catch block* available or can handle the raised exception
  - ➢ Handle the exception in the calling function/altstep/testcase

- Dynamic **error**, if exception not handled at the latest *catch* clause of the testcase statement block

Exception handling samples

(1) execution continues in catch-block

```
function f_myf1() exception (integer) {…
    raise integer:1;
} catch (integer p_i) {…}
```

(2) execution continues outside

```
function f_myf1() exception (integer) {…
    raise integer:1;
}
```

Exception handling – application example

- Simplification of post processing in case of error handling
- E.g. resource creation and/or resource releases
- Initialization scenario based on sub-processes for registration and request message

Exception handling – application example

```
function f_create(in charstring p_name) exception (charstring, integer)
         runs on myComponent
  {var integer v_rc:=-1;
   …
   if (not fx_register(p_name)){
      raise ("Could not register" & p_name);}
   …
   if (not f_sendRequest(p_name, v_rc)){
      raise (v_rc+1000);}
   …}
catch (charstring p_c)
  {log("Initialization failed: ", p_c); setverdict(inconc)…}
catch (integer p_i)
  {log("Creation failed with return code: ", p_i); setverdict(fail);…}
```

match 1st catch

match 2nd catch

Conclusions

Key takeaways

- Enhancements for TTCN-3 programmers
- Attraction of new users
- Ongoing maintenance and improvements by ETSI TTF

Q&A

For further information please visit www.ttcn-3.org

and/or contact ETSI TC MTS via www.etsi.org/MTS.

Team: https://portal.etsi.org/STF/STFs/STF-HomePages/T003

Community: http://www.ttcn-3.org/index.php/community/contact

Suggestions: http://www.ttcn-3.org/index.php/community/change-requests

Short summary on TTCN-3 in general (Webinar part 1)

- Abstract test definition language
  - Used in multiple industrial domains
  - One testing technology for all testing types:
    functional (conformance, functions) and non-functional (performance, security, vulnerability)
- Long history in standardization (ISO, ITU-T and ETSI)
- Independent from programming languages
  - Includes testing specific features
  - Mappings to Java, C++, C#
  - Extensibility via attributes, external functions etc.
  - Integration with different languages like JSON, XML, ASN.1, IDL
- Earlier versions were lacking modern OO features

Test component and port concepts of TTCN-3

- Test components are independent entities
  - Each one is running a piece of the whole test case behaviour…
  - and owning its own data and objects
  - MTC – Main test component
    is created automatically
  - PTC – Parallel test component(s)
    created dynamically
- Communicating with each other and with the SUT via ports
  - Defined sets of incoming & outgoing messages,
    and procedure calls & responses