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TECHNICAL REPORT

Intelligent Transport Systems (ITS);
Architecture of conformance validation framework

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

Modal verbs terminology

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Introduction

In response to EC mandate M/453 [i.10], ETSI Technical Committee (TC) ITS has standardized base and test specifications for ITS protocols. In a next step a prototype TTCN-3 test system was built and validated. The present document describes the design and validation of the prototype TTCN-3 test system.

The action described in the present document has supported the implementation of ITS standards by:

- Making available validated and standardized test specifications and thus enabling the application of reliable certification schemes.
- Executing conformance validation framework against real Implementations Under Test (IUTs) from industry and thus providing these companies a conformance assessment of their implementations. During the lifetime of this action, the conformance validation framework was as well provided at ITS Cooperative Mobility Services Interoperability events.
- Releasing all software as open source and thus allowing industry to build and run their own conformance validation framework.

1 Scope

The present document provides a description of the architecture of the ITS conformance validation framework, including definition of the test environment, codec and test adapter. It provides, as well, all the necessary source code to build and run the ITS conformance validation framework.

The ITS conformance validation framework integrates the test suites ETSI TS 102 871-3 [i.4], ETSI TS 102 868-3 [i.5], ETSI TS 102 869-3 [i.6], ETSI TS 102 870-3 [i.7], ETSI TS 102 859-3 [i.8] and ETSI TS 103 191-3 [i.9].

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 reference document (including any amendments) applies.

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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 201 873-5 (V4.5.1): "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 5: TTCN-3 Runtime Interface (TRI)".

[i.2] ETSI EG 201 015 (V2.1.1): "Methods for Testing and Specification (MTS); Standards engineering process; A handbook of validation methods".

[i.3] IEEE 802.11p™: "IEEE Standard for Local and Metropolitan Area Networks - Specific requirements; Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; Amendment 6: Wireless Access in Vehicular Environments".

[i.4] ETSI TS 102 871-3 (V.1.3.1): "Intelligent Transport Systems (ITS); Testing; Conformance test specifications for GeoNetworking ITS-G5; Part 3: Abstract Test Suite (ATS) and Protocol Implementation eXtra Information for Testing (PIXIT)".

[i.5] ETSI TS 102 868-3 (V.1.3.1): "Intelligent Transport Systems (ITS); Testing; Conformance test specifications for Cooperative Awareness Basic Service (CA); Part 3: Abstract Test Suite (ATS) and Protocol Implementation eXtra Information for Testing (PIXIT)".

[i.6] ETSI TS 102 869-3 (V.1.4.1): "Intelligent Transport Systems (ITS); Testing; Conformance test specifications for Decentralized Environmental Notification Basic Service (DEN); Part 3: Abstract Test Suite (ATS) and Protocol Implementation eXtra Information for Testing (PIXIT)".

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[i.7] ETSI TS 102 870-3 (V.1.1.1): "Intelligent Transport Systems (ITS); Testing; Conformance test specifications for Geonetworking Basic Transport Protocol (BTP); Part 3: Abstract Test Suite (ATS) and Protocol Implementation eXtra Information for Testing (PIXIT)".

[i.8] ETSI TS 102 859-3 (V.1.2.1): "Intelligent Transport Systems (ITS); Testing; Conformance test specifications for Transmission of IP packets over Geonetworking; Part 3: Abstract Test Suite (ATS) and Protocol Implementation eXtra Information for Testing (PIXIT)".

[i.9] ETSI TS 103 191-3 (V.1.1.1): "Intelligent Transport Systems (ITS); Testing; Conformance test specifications for Signal Phase And Timing (SPAT) and Map (MAP); Part 3: Abstract Test Suite (ATS) and Implementation eXtra Information for Testing (IXIT)".

[i.10] EC mandate M/453: "Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of Information and Communication Technologies to support the interoperability of co-operative systems for Intelligent Transport in the European Community".

3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AC	Adapter Control
ACC	Adaptive Cruise Control
API	Application Programming Interface
ASN	Abstract Syntax Notation
AT	Authorization Ticket
ATS	Abstract Test Suite
BTP	Basic Transport Protocol
BTP-A	Basic Transport Protocol - Type A
BTP-B	Basic Transport Protocol - Type B
CAM	Cooperative Awareness Message
CC	Cruise Control
DENM	Decentralized Environmental Notification Message
EC	European Commission
ETH	ETHernet
GN	GeoNetworking
HB	High Beam
IP	Internet Protocol
ITS	Intelligent Transportation Systems
ITS-S	Intelligent Transportation Systems - Station
IUT	Implementation Under Test
JDK	Java™ Development Kit
LB	Low Beam
LS	Location Service
LT	Left Turn
MAC	Media Access Control
MAP	MapData
MTC	Main Test Component
OS	Operating System
OSI	Open Systems Interconnection model
PC	Personal Computer
Pcap	Packet capture
PDU	Protocol Data Unit
PICS	Protocol Implementation Conformance Statement
RT	Right Turn
SHB	Single Hop Broadcast
SPAT	Signal Phase And Timing
SUT	System Under Test
TA	Test Adapter
TC	Test Cases
TCI	TTCN-3 Control Interface
TP	Test Purposes

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TRI	TTCN-3 Runtime Interface
TSB	Topology Scoped Broadcast
TTCN-3	Testing and Test Control Notation 3
UDP	User Datagram Protocol
UT	Upper Tester
XP	Windows™ XP operating system

4 Test platform overview

4.1 Constraints and requirements

The purpose of the ITS test platform is to provide a reliable set of software and hardware equipments that can be used to validate TTCN-3 abstract test suites (ATS) developed in ETSI.

The architecture of this test platform has been designed with respect to the following constraints:

- to be compatible with the requirements expressed in the validation handbook (ETSI EG 201 015 [i.2]);
- to be independent of the platform used to implement the test system;
- to be independent of the TTCN-3 tool provider;
- to be configurable and customizable;
- to provide tools and well defined interfaces to system under test (SUT), allowing test automation;
- to be easily extensible for future ITS protocols;
- to provide generic components that can be reused in other test platforms.

In order to ensure independence of hardware platforms, all software pieces running on the test platform have been implemented using Java™ language, using generic and widely used libraries.

Test tool independence has been achieved by isolating the tool specific interfaces from core functionalities of the platform. Adapting the current platform to a different test tool would only require the implementation of a very simple piece of software mapping tool-specific functions to generic functions defined in this project.

In addition, great care has been taken to separate ITS specific functionalities from generic test platform tasks in order to provide a maximum number of reusable components for future test platforms.

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4.2 General architecture

Typically a TTCN-3 test platform is composed of four different components:

- The TTCN-3 test tool providing necessary software to execute the abstract test suites.
- The hardware equipment supporting TTCN-3 test execution and adaptation to SUTs.
- The codecs which convert protocol messages into their abstract TTCN-3 representation.
- The Test Adapter (TA) implementing interfaces with the device under test.

The interaction of these components is described in figure 1.

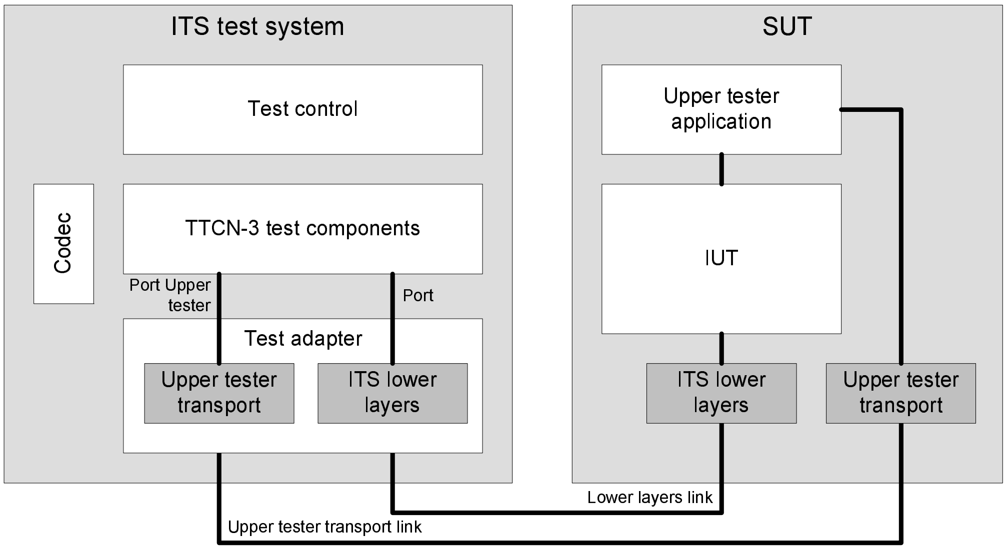

Figure 1: General architecture

The TTCN-3 test tools are usually provided by commercial companies and their description is out of the scope of the present document. The implementation details of the other components are described in the present document.

5 Hardware equipment

5.1 PC

The main hardware component of the ITS test platform is a standard PC. Its role is to host the execution of the test suites using a commercial TTCN-3 test tool.

Whatever operating system is installed on the computer, it is necessary to ensure that the following points are taken into account:

- No firewall interference with traffic generated by the Test System and/or SUT.
- Excellent time synchronization between the SUT and the test system.
- Test system processes (especially the test adapter) have to be granted unrestricted control to telecommunication hardware.

Time synchronization is maybe the most critical point to be checked before starting any test session, as it can be the source of strange SUT behaviour and generate incoherent results. Indeed, most ITS protocol messages feature a time tag used by the receiver to determine if the information it carries is still valid; if the test system is ahead in time, all messages it sends will be considered either as coming from the future or from a very old date, and be discarded.

This PC is equipped with two network cards, one being used for ITS communication with SUT (lower layers link), the other one being used for exchanging upper tester messages (upper tester transport link). Separating these two communications on different hardware interfaces is not an absolute necessity, but it is a good practice and it ensures that there will be no interaction between the flows.

The communication between the SUT and the test system is achieved through Ethernet if the SUT supports it or using a G5 adaptation box, as shown in figure 2 and in figure 3.

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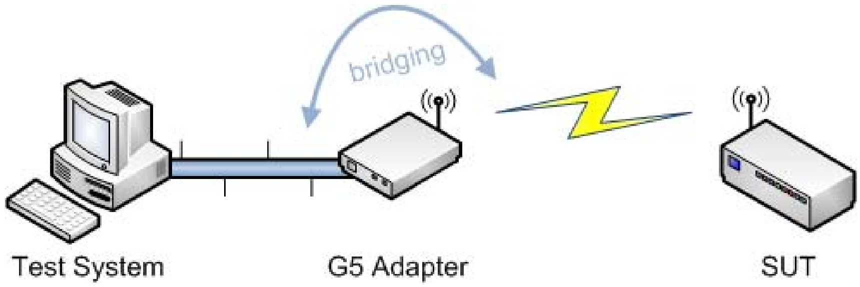

Figure 2: Communication via G5 adaptation box

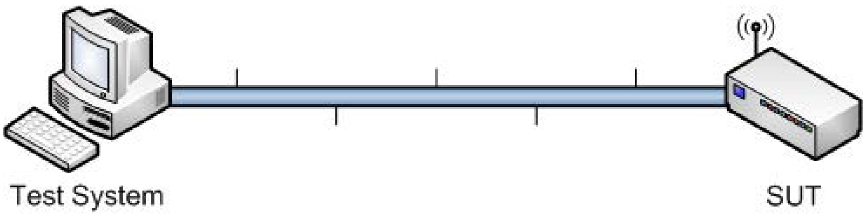

Figure 3: Communication via Ethernet

5.2 G5 adapter box

The ITS protocol stack makes use of G5 radio protocol in order to establish communication between ITS devices. To achieve G5 connectivity, a dedicated hardware equipment needs to be added to the test platform. The role of this adaptation box is to handle all radio-related tasks transparently and to act as a bridge for the test system.

Cohda Wireless™ MK2 has been chosen to fulfil this task. This device is fully IEEE 802.11p [i.3] compliant and provides as well an Ethernet interface so that it can be used as a transparent bridge between the test system and the SUT, as depicted in figure 2.

To transfer frames received on the Ethernet interface to the radio interface and vice versa, it is necessary to install and execute a small bridge application on the MK2. Only the frame featuring a specific ethertype (0x0707 by default) will be transferred from one interface to the other, so that only desired traffic will cross the bridge.

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6 Codecs

6.1 Introduction

The codec entity is responsible for the encoding and decoding of TTCN-3 abstract values into bitstrings suitable to be sent to the System Under Test (SUT).

In order to simplify implementation and to ease the maintenance, coding and decoding tasks are handled by several codecs:

- One independent codec package per tested protocol;
- One codec package for TTCN-3 types that do not correspond to real protocol messages. It includes for example all auxiliary types used to carry information to/from Test Adapter, like the ones defined in TestSystem modules (CoapInd, CoapReq, etc.);
- One generic codec package available for handling default codec operation non related to any specific protocol. Theses codecs will be used if no protocol-specific codec exists for one type.

6.2 Advanced details of implementation

Figure 4 gives an overview of the relations between the different Java™ classes implementing the codecs. Connection with the tool-dependent classes is realized through the ITERquired interface and the associated factory class.

Each codec is responsible for correctly encoding and decoding one specific type and implements the ICodec interface.

Selection of correct codec for encoding or decoding a message at runtime is managed by the CodecFactory class, via the getCodec() method. This method will select the appropriate codec based on three parameters:

- the `type name`;
- the `encoding` as specified in TTCN-3 modules using "with encode" statements;
- the `type class` (record, union, etc.).

The rules for selecting the correct codec are the following:

1) If a codec is registered for `type name` in the package corresponding to `encoding`, then select this codec and call encode() or decode() method;

2) Otherwise, if a codec is registered for `type class` in the package corresponding to `encoding`, then select this codec and call encode() or decode() method;

3) Otherwise, use codec corresponding to `type class` in `generic` package.

This design provides both flexibility and easy extensibility. For most protocols, the "generic" codec package will handle most of the encoding and decoding operations. Specific encoding processes can be handled case by case by adding minimal codecs and registering them in the CodecFactory.

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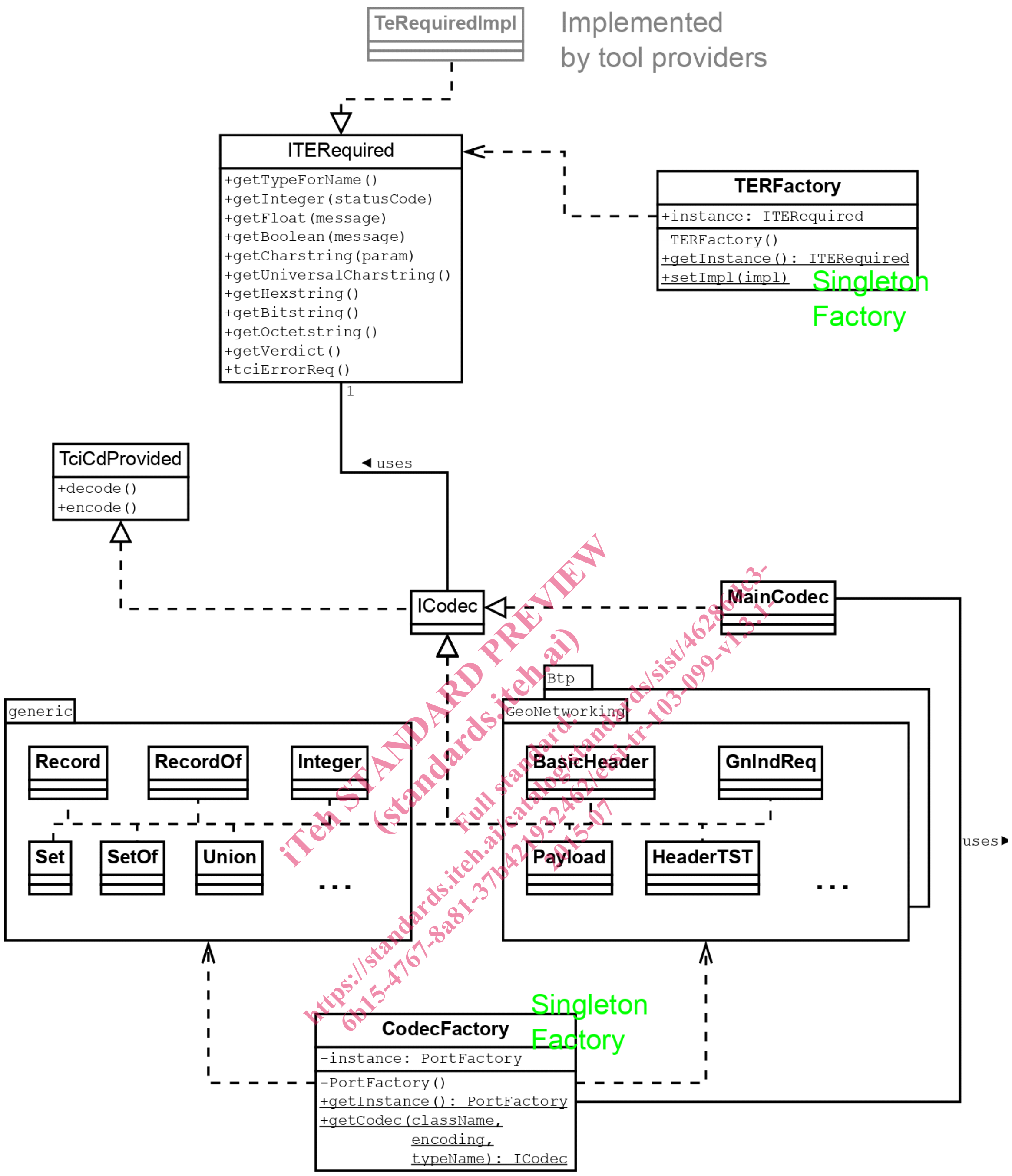

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Figure 4: Codec class diagram

7 Test Adapter

7.1 Introduction

The test adapter conceptually splits into three parts:

- a lower test adapter;
- a TTCN-3 platform adapter implementing timers;
- an upper test adapter.