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TECHNICAL REPORT

**Core Network and Interoperability Testing (INT);
Coding Guidelines for TTCN-3 Libraries
Based on the Example of the SIP and IMS TTCN-3 Libraries**

Reference

DTR/INT-00099

Keywords

IMS, INT, SIP, TTCN-3

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Core Network and Interoperability Testing (INT).

Modal verbs terminology

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1 Scope

The present document describes guidelines for the production of TTCN-3 libraries for protocol families or whole technologies. TTCN-3 is the Testing and Test Control Notation version 3 as defined in ETSI ES 201 873-1 [i.1].

The guidelines are based on the overhaul work performed on two TTCN-3 libraries that have been in use for several years in the production of abstract test suites (ATS) for testing IMS components: LibSip and LibImS.

LibSip is a collection of reusable TTCN-3 definitions related to SIP standards including type definitions for the SIP base IETF RFC 3261 [i.3] and other RFCs extending the scope, SIP templates and functions for sending and receiving SIP requests and answers.

LibImS is a collection of reusable TTCN-3 definitions extending LibSip to cover IMS specific aspects as defined in ETSI TS 124 229 [i.2]. LibImS is made up of TTCN-3 modules that extend the modules of LibSip from IETF style SIP as found in IETF RFC 3261 [i.3] to IMS SIP as described in ETSI TS 124 229 [i.2].

2 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 <http://docbox.etsi.org/Reference>.

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2.1 Normative references

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

Not applicable.

2.2 Informative references

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 201 873-1: "Methods for Testing and Specification (MTS); The Testing and Test Control Notation version 3; Part 1: TTCN-3 Core Language".
- [i.2] ETSI TS 124 229: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3 (3GPP TS 24.229)".
- [i.3] IETF RFC 3261 (2002): "SIP: Session Initiation Protocol".
- [i.4] ETSI TS 186 009-3: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Interworking between Session Initiation Protocol (SIP) and Bearer Independent Call Control Protocol (BICC) or ISDN User Part (ISUP); Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT)".
- [i.5] ETSI TS 186 005-3: "IMS Network Testing (INT); Terminating Identification Presentation (TIP) and Terminating Identification Restriction (TIR) Conformance Testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".

- [i.6] ETSI TS 186 007-3: "IMS Network Testing (INT); Communication HOLD (HOLD) using IP Multimedia (IM) Core Network (CN) subsystem; Conformance Testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.7] ETSI TS 186 010-3: "IMS Network Testing (INT); Conference (CONF) using IP Multimedia (IM) Core Network (CN) subsystem; Conformance Testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.8] ETSI TS 186 014-3: "IMS Network Testing (INT); Communication Diversion (CDIV) using IP Multimedia (IM) Core Network (CN) subsystem; Conformance Testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.9] ETSI TS 186 016-3: "Technical Committee for IMS Network Testing (INT); Closed User Group (CUG); Conformance Testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.10] ETSI TS 186 017-3: "Technical Committee for IMS Network Testing (INT); Anonymous Communication Rejection (ACR) and Communication Barring (CB) conformance testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.11] ETSI TS 186 018-3: "IMS Network Testing (INT); Malicious Communication Identification (MCID) Conformance Testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.12] ETSI TS 186 022-3: "IMS Network Testing (INT); Communication Waiting (CW) using IP Multimedia (IM) Core Network (CN) subsystem; Conformance Testing; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.13] ETSI TS 102 890-3: "Intelligent Transport System (ITS); Facilities layer function; Position and time facility specification".
- [i.14] ETSI TS 186 001-4: "IMS Network Testing (INT); Network Integration Testing; Part 4: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.15] ETSI TS 186 011-3: "IMS Network Testing (INT); IMS NNI Interoperability Test Specifications; Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT)".
- [i.16] ETSI TS 101 580-3: "Core Network and Interoperability Testing (INT); Diameter Conformance testing for Rx interface (3GPP Release 10); Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.17] ETSI TS 101 606-3: "Core Network and Interoperability Testing (INT); Diameter Conformance testing for Gx interface (3GPP Release 10); Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.18] ETSI TS 102 790-3: "Core Network and Interoperability Testing (INT); IMS specific use of Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Conformance Testing; (3GPP Release 10); Part 3: Abstract Test Suite (ATS) and partial Protocol Implementation eXtra Information for Testing (PIXIT) proforma specification".
- [i.19] ETSI TS 123 040: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Technical realization of the Short Message Service (SMS) (3GPP TS 23.040)".
- [i.20] ETSI TS 124 011: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Point-to-Point (PP) Short Message Service (SMS) support on mobile radio interface (3GPP TS 24.011)".

- [i.21] ETSI TS 124 341: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); LTE; Support of SMS over IP networks; Stage 3 (3GPP TS 24.341)".
- [i.22] IETF RFC 3262: "Reliability of Provisional Responses in the Session Initiation Protocol (SIP)".
- [i.23] IETF RFC 3265: "Session Initiation Protocol (SIP)-Specific Event Notification".
- [i.24] IETF RFC 3313: "Private Session Initiation Protocol (SIP) Extensions for Media Authorization".
- [i.25] IETF RFC 3323: "A Privacy Mechanism for the Session Initiation Protocol (SIP)".
- [i.26] IETF RFC 3325: "Private Extensions to the Session Initiation Protocol (SIP) for Asserted Identity within Trusted Networks".
- [i.27] IETF RFC 3326: "The Reason Header Field for the Session Initiation Protocol (SIP)".
- [i.28] IETF RFC 3327: "Session Initiation Protocol (SIP) Extension Header Field for Registering Non-Adjacent Contacts".
- [i.29] IETF RFC 3329: "Security Mechanism Agreement for the Session Initiation Protocol (SIP)".
- [i.30] IETF RFC 3455: "Private Header (P-Header) Extensions to the Session Initiation Protocol (SIP) for the 3rd-Generation Partnership Project (3GPP)".
- [i.31] IETF RFC 3515: "The Session Initiation Protocol (SIP) Refer Method".
- [i.32] IETF RFC 3608: "Session Initiation Protocol (SIP) Extension Header Field for Service Route Discovery During Registration".
- [i.33] IETF RFC 3841: "Caller Preferences for the Session Initiation Protocol (SIP)".
- [i.34] IETF RFC 3891: "The Session Initiation Protocol (SIP) "Replaces" Header".
- [i.35] IETF RFC 3892: "The Session Initiation Protocol (SIP) Referred-By Mechanism".
- [i.36] IETF RFC 4028: "Session Timers in the Session Initiation Protocol (SIP)".
- [i.37] IETF RFC 4244: "An Extension to the Session Initiation Protocol (SIP) for Request History Information".
- [i.38] IETF RFC 4488: "Suppression of Session Initiation Protocol (SIP) REFER Method Implicit Subscription".
- [i.39] IETF RFC 5009: "Private Header (P-Header) Extension to the Session Initiation Protocol (SIP) for Authorization of Early Media".
- [i.40] IETF RFC 6442: "Location Conveyance for the Session Initiation Protocol".
- [i.41] IETF draft-johnston-sipping-cc-uu: "Transporting User to User Call Control Information in SIP for ISDN Interworking".
- [i.42] IETF RFC 2617: "HTTP Authentication: Basic and Digest Access Authentication".
- [i.43] IETF RFC 5031: "A Uniform Resource Name (URN) for and Other Well-Known Services".
- [i.44] 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 Abbreviations

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

ATS	Abstract Test Suite
EPC	Extended Packet Core
IMS	IP Multimedia core network Subsystem
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part
ITS	Intelligent Transport Systems
LTE	Long Term Evolution
PIXIT	Protocol Implementation eXtra Information for Testing
SDP	Session Description Protocol
SIP	Session Initiation Protocol
SMS	Short Message Service
STF	Specialized Task Force
TTCN-3	Testing and Test Control Notation version 3
XML	eXtensible Markup Language

4 Coding Guidelines for TTCN-3 Libraries

The following clauses describe guidelines for coding of TTCN-3 modules for libraries. TTCN-3 libraries usually offer functionality for a certain protocol (e.g. SIP, DIAMETER) or a technology (e.g. IMS) and are then referenced by all test specifications that test aspects of those protocols/technologies. The guidelines have been developed based on the example of an overhaul of the libraries LibSip and LibImS.

Clause 5 describes the aspects that are specific to LibSip and LibImS and also gives an overview of the contents of all TTCN-3 modules and the applied test architecture (Supported interfaces, ports, etc.).

4.1 Use of Module Parameters

Generally it should be avoided to use Module Parameters in a common library, especially Test Suite specific ones.

A lot of times Module Parameters are confusing for new library users/adopters/beginners. Module Parameters do not always have a default value. This may cause run-time errors when an uninitialized Module Parameter is used by the TTCN-3 run-time environment.

As the user of the library will in most cases only use a subset of the functionality and templates provided, a defined module parameter might not be used – but potentially the tooling will still present it in the module parameter list and though might lead to an unnecessary long list.

One way to reduce the number of Module Parameters is to parameterize functions/templates where configurable values are required. The advantage of this approach from the common library point of view, is that the user of a function/template will have to provide the values when he wants to use that functionality, otherwise the code will not compile. There is also no need to preconfigure the library before it can be used. The drawback is, it requires a new additional parameter for every Module Parameter removed, and can cause some top-level functions/templates to have too many parameters. While there is no limit on the parameter count from a TTCN-3 specification point of view, this does increase complexity and the amount of typing required for the user of said code. If the module parameters were used to initialize component variables, an initialization function should be introduced to initialize the component parameters with a concrete values. This way, users of the library can decide how the values are provided, e.g. from a user defined module parameter or dynamically.

4.2 Correct Use of Template and Functions

This implies that items mentioned below should be used "in a proper way". Naming conventions should be chosen, this will help to reduce the adoption time required to start using the template/function.

4.2.1 Parameters

The problem with some of the parameters is that although defined, they might not be used. This requires a value to be passed along every time a function/parameterized template is referenced. In some of the cases, this is a result of a function behaviour change, and this parameter is not required anymore.

In other cases it might be that a parameter was required, added, but not taken into use because of a constant or a variable with a similar name.

If possible, a default value should be set for a parameter. Parameters that have a "template" modifier should also have a "template restriction" (value, present, omit) mechanism applied to them. This increases the quality of the code by limiting range of possible input values and reduces the number of unexpected run-time errors in the future.

4.2.2 Duplicate Resolution

Some of the templates duplicate each-other, or have a common part that is repeated over and over again. For templates that differ in some parts, a common "base" template can be created, then by using the "modifies"-statement specific templates can be created from the base one. It also makes sense to create a parameterized template, for example if the range of field values is not known beforehand.

Duplicated code is also an issue for function/altstep behaviour. Re-used code should be moved into separate functions. This simplifies code maintenance and promotes re-usability.

4.2.3 Inline Templates

Usage of inline template is discouraged. It is acceptable to use inline templates for instances of simple types and simple structures. A properly named template instance will make the readability and understanding of the code much simpler. A global template definition will also make the maintenance of code much easier, as there is no need to search and update every instance of a particular inline template.

4.3 Consistent Formatting and Layout

Common TTCN-3 definition items should be separated into different modules. Modules can use suffixes that identify what type of content they have, for example:

- ..._TypesAndValues - for modules containing all types and fixed predefined values (constants)
- ..._Templates - for modules containing templates
- ..._Functions - for basic/simple functions and altsteps
- ..._Steps - for complex procedures and altsteps
- ..._PIXITS - for collections of Module Parameters
- ..._Interface - for communication port and component type definitions
- Etc.

Note that ETSI naming convention is used here, in case any other convention is used, the same logic for naming modules should be applied.

It is also important to group items logically, by using the built-in TTCN-3 grouping mechanism. For example, templates used for a particular purpose. It is very common to group templates intended for sending and templates intended for receiving separately. The difference is that send templates do not contain any matching mechanisms and can be used for both sending and receiving. While receiving templates contain matching mechanisms and cannot be used for sending.

Grouping together with a proper naming convention make it easy to navigate through code and look for templates of particular interest.

All modules should have the same layout and formatting applied to them. One of the most common overlooked issues is the use of specific indentation. While it is not noticeable in case only a single TTCN-3 editing tool is used during development, issues arise when source files are viewed in a different tool. Most commonly with TAB character having a different width, making the code misaligned and difficult to read and giving the impression of low quality code. Solution is to use a certain number of SPACE characters instead of TAB, 4 SPACE characters have the same width as a single TAB for most monospaced fonts used in editors. Because developers might prefer different editors with different settings, it makes sense to review all modules and apply a common formatting for all TTCN-3 modules after the development is finished.

4.4 Warning Free Code

The general idea is to reduce the amount of warnings generated by a specific TTCN-3 compilation tool to a minimum. Distinction has to be made between warnings produced for actual issues that are caused by an improper use of TTCN-3 constructs and potential issues identified by the tool's analysis algorithm. One common example is the "sizeof"/"lengthof" built-in function behaviour. In earlier versions of TTCN-3 there used to be only the "sizeof" function, then the "lengthof" function was introduced into TTCN-3. Old "sizeof" functionality was moved to the new lengthof, while different functionality was defined for "sizeof". This change in the TTCN-3 standard will cause all code written before "lengthof" to suddenly stop working. As a workaround all major TTCN-3 tool providers introduced a warning to notify the user of incorrect "sizeof" use. While future changes to TTCN-3 behaviour cannot be predicted, one possible resolution is to instruct TTCN-3 compilers to use a specific version of TTCN-3 with the "language" construct. This approach was not applied to LibSip and LibImS, because the common understanding is that using the latest TTCN-3 compiler version is always better than locking code for some old (and possibly obsolete in the future) TTCN-3 version. Besides, the ability to use a compiler for a specific TTCN-3 version is not a mandatory feature of any TTCN-3 tool, and simply may not be present.

Other kind of warnings are the result of code analysis indicating that some values assigned might be out of range of the target variable type. Although this kind of warning can point out potential issues, it sometimes cannot be completely resolved, as some intermediate variable states might not satisfy some restriction, while the final result does.

Warnings do not always indicate problems with the code. Some of the warnings might be because the TTCN-3 standard itself has evolved and/or the behaviour has been changed or restricted.

4.5 Use of T3Doc

ETSI ES 201 873-10 [i.44] describes the TTCN-3 Documentation Comment Specification and defines a set of language tags for the annotation of text to be used for the automatic generation of test suite documentation documents. According to that standard different kind of tags are specific for dedicated TTCN-3 language elements where others are to be used for all language constructs. In principle as many as possible of such documentation tags should be applied (to ease the maintenance work for developers). However, the use of T3Doc for the subset of definitions to be known by users, e.g. description of modules (author, version, reference, etc.), module parameters and external functions is a minimal requirement.

4.6 Further recommendations

All TTCN-3 log statements should have the following format:

- Three asterisks should be used to precede the log text.
- The TTCN-3 test case/function identifier in which the log statement is defined should follow.
- One of the categories INFO, WARNING, ERROR, PASS, FAIL, INCONC, TIMEOUT should follow.
- Free text should follow.
- And the log text should end with three asterisks.

EXAMPLE: `log("*** f_sendMsg: INFO: Message has been sent ***")`

Any invocation of an external function should be followed by a log statement.

Each TTCN-3 setverdict statement that sets a test component verdict to INCONC or FAIL should be preceded by a log statement or a log statement feature as first defined in TTCN-3 version 3.4.1 should be used, where the comment is part of the setverdict statement.

In order to keep the readability, consistency and maintainability of the TTCN-3 code, functions/altsteps are implemented following a certain structure. The present document defines this structure as follows:

- Local variables, contain the declaration of the variables to be used within the function/altstep.
- Initialization of component variables contains zero or more assignments that initialize or modify the value of component variables.

4.7 Quality Checking

4.7.1 Use of TTCN-3 Tools

It is in the interest of the library developer to test code compilation with as many different TTCN-3 tools as possible. This tremendously increases code quality and compliance to the TTCN-3 specification. Combined with the warnings produced by different tools, it increases the chances of the code running on future, more restrictive versions of TTCN-3 tools and tools that are not publicly available or still in development. General trend for TTCN-3 Core language specification is to remove ambiguous functionality which is open for interpretation and add new language features.

4.7.2 Use of T3Q

T3Q is a powerful tool for quality checking TTCN-3 code. The tool is configured with an XML file, specific configuration values are out of scope of the present document.

Although T3Q revealed issues in virtually all of the processed categories, most issues were related to the following items:

- 1) Naming conventions
- 2) Formatting
- 3) Definition order
- 4) Unused imports, formal parameters, local definitions
- 5) Presence of in-line templates
- 6) Definition of a function/template/type inside the wrong module.

For the complete list of quality checks and tool guide, refer to the T3Q documentation:

<http://t3tools.informatik.uni-goettingen.de/trac/wiki/Documentation/T3Q>

Every single issue identified by the tool was processed individually. While processing the list, we identified that not all reported issues are caused by problems with the TTCN-3 code. In general, the list can be divided into 3 categories:

- 60 % caused by problems with the code.
- 30 % caused by T3Q tool applying incorrect rule to a definition (e.g. Message template rule applied to a template with a reference to a template containing matching mechanism).
- 10 % exceptions to general rules (see comments below):
 - Single ETSI Generic naming convention was applied for all modules. Local variable names under 3 characters in length were ignored, e.g. having every "counter" variable comply with a variable naming convention is not critical.
 - Some of the definitions specific to SIP/SDP/SMS/XML have an all upper-case "SIP"/"SDP"/"SMS"/"XML" letter sequence in the name, although against the naming convention. Those definition names were left unmodified.

- "SIPP" port instance name was not changed because of historical reasons.
- Definition order was not followed for some very specific categories, for example all items related to TTCN-3 "address" were left together.
- Unreferenced constants are kept in the library, this is intentional for libraries.
- Types defined by STF160 do not comply with ETSI Generic naming convention used in the rest of the LibSip.

T3Q verification should not be applied to code automatically generated by the use of external ASN.1/XSD modules. All names are generated according to the corresponding mapping specification, independent of any naming convention used in other parts of the library.

4.7.3 External Types

Most commonly, TTCN-3 modules import type definitions from ASN.1 and/or XSD schema. While mapping of types is standardized, implementation may vary. Some tools do an implicit conversion and the intermediate output is not presented to the user, while other tools do an explicit conversion. Result of an explicit conversion is a TTCN-3 module containing types according to the mapping specification. The generated modules often contain tool specific attributes for the codec (ASN.1, XML) and other components. This is why it is always recommended to supply source files for imported data without generated mapping output.

5 LibSip and LibImS Version 3 Libraries

LibSip is a collection of reusable TTCN-3 definitions related to SIP standards including type definitions for the SIP base IETF RFC 3261 [i.3] and other RFCs extending the scope, SIP templates and functions for sending and receiving SIP requests and answers. The present version 3 is not backward compatible to the old 1.7 and 2.0 versions since it changes e.g. types and templates related to header fields, parameters of functions, etc.

LibImS is a collection of reusable TTCN-3 definitions extending LibSip to cover IMS specific aspects as defined in ETSI TS 124 229 [i.2]. LibImS is made up of TTCN-3 modules that extend the modules of LibSip from IETF style SIP as found in IETF RFC 3261 [i.3] to IMS SIP as described in ETSI TS 124 229 [i.2].

This clause describes the aspects that are specific to LibSip and LibImS and gives an overview of the historical background of these 2 libraries, as well as the contents of all TTCN-3 modules and applied test architecture (supported interfaces, ports, etc.).

5.1 Historical Background

The protocol conformance of devices running IMS protocols is assessed through testing against test tools running conformance test suites based on TTCN-3 code as defined in ETSI ES 201 873-1 [i.1] developed by ETSI Specialist Task Forces (STF).

At the start of ETSI's IMS testing activities in 2008 STF346 developed a set of TTCN-3 libraries containing all the necessary basic features for testing IMS equipment. Two libraries have been developed, one covering the "pure" SIP requirements as described in IETF RFC 3261 [i.3] and one that adds the additional requirements as described in the IMS protocol standards, namely ETSI TS 124 229 [i.2]. The libraries have been named LibSip and LibImS.

LibSip contains the TTCN-3 definitions related to SIP standards including type definitions for the SIP base in IETF RFC 3261 [i.3] as well as other RFCs, SIP templates and functions for sending and receiving SIP requests and answers.

LibImS contains the TTCN-3 definitions extending LibSip to cover IMS specific aspects as defined in ETSI TS 124 229 [i.2] and related IMS base specifications. LibImS is made up of TTCN-3 modules that extend the modules of LibSip from IETF style SIP to IMS SIP.

Since their initial development the two libraries have been used as the input for a number of STFs producing thousands of conformance, interoperability and interworking test cases. Please see Annex A for details.

5.2 Structure

5.2.1 LibSip

The current version 3 of LibSip consists of 14 TTCN-3 modules that can be illustrated as given in figure 1 reflecting the hierarchy following the import relationships from the source code. According to these relations modules from lower levels are used by the modules from the upper levels.

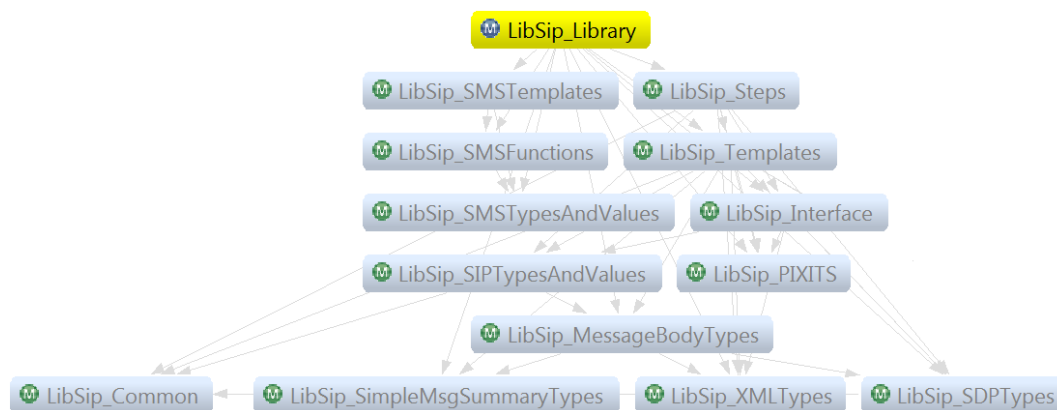


Figure 1: Module import relations in LibSipV3

Table 1 shortly introduces the content of the LibSipV3 library modules.

Table 1: LibSipV3 modules and their content

Module Name	Content
LibSip_Common	This module provides the common definitions for SIP messages.
LibSip_Interface	This module provides the types used by the test component for SIP-IMS tests.
LibSip_Library	This module provides all modules of the LibSip as public imports.
LibSip_MessageBodyTypes	This module provides the types used for alternative SIP message body variants and combinations.
LibSip_PIXITS	This module provides module parameters used within the SIP protocol for timers, SDP formats, etc.
LibSip_SDPTypes	This module defines message, attribute, structured and simple SDP types as well constants used by LipSip constructs.
LibSip_SimpleMsgSummaryTypes	This module provides the SMS type system for SIP tests.
LibSip_SIPTypesAndValues	This module defines message, header, structured and simple SIP types as well constants used by LipSip constructs.
LibSip_SMSFunctions	This module provides the functions used by the test component for SIP-SMS over IMS as specified in ETSI TS 124 341 [i.21] tests.
LibSip_SMSTemplates	This module provides the types used by the test component for SIP-SMS over IMS as specified in ETSI TS 124 341 [i.21] tests.
LibSip_SMSTypesAndValues	This module contains the type definitions for SMS messages as specified in ETSI TS 124 011 [i.20] and ETSI TS 123 040 [i.19] Rel 8 and 9.
LibSip_Steps	This module provides the functions, altsteps and external functions used for SIP-IMS tests.
LibSip_Templates	This module defines SIP Templates for message, header, and structured types.
LibSip_XMLTypes	This module provides the XML type system for SIP tests.

The current LibSipV3 version also includes the following set of XSD files that may be imported for the definition of TTCN-3 templates: ACR_CB.xsd, CDIV.xsd, CDIVN.xsd, common-policy.xsd, CONF.xsd, cug.xsd, cw.xsd, geopriv10basic.xsd, Ims3gpp.xsd, MCID.xsd, OIP-OIR.xsd, pidf.xsd, pidf_lo.xsd, PSTN.xsd, regInfo.xsd, ResourceList.xsd, simservs.xsd, SupplementaryServices.xsd, TIP-TIR.xsd, xdm_commonPolicy-v1_0.xsd, xml.xsd.

5.2.2 Liblms

In Liblms several templates and functions do import related declarations from LibSip version 3. This allows a simple structure and overview for Liblms.

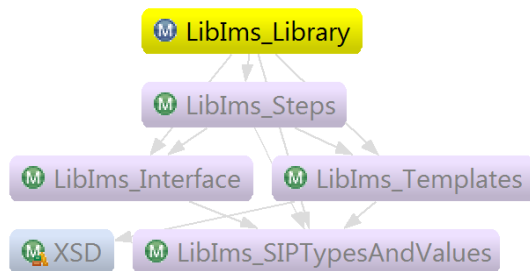


Figure 2: Module import relations in LiblmsV3

Table 2 shortly introduces the content of the LiblmsV3 library modules.

Table 2: LiblmsV3 modules and their content

Module Name	Content
Liblms_Interface	This module provides the component type for SIP-IMS tests.
Liblms_Library	This module provides all modules of the Liblms as public imports.
Liblms_SIPTypesAndValues	This module provides the types and constants used by the test component for SIP tests.
Liblms_Steps	This module provides the steps used by the test component for SIP-IMS tests.
Liblms_Templates	This module provides the templates used by the test component for SIP-IMS tests.

5.3 Configuration

SIP components based on LibSipV3 include communication ports to change SIP messages (SipPort) and to apply operator procedures (OperatorPort). If several parallel SIP components are to be executed synchronization may take place via synchronization ports as part of the ETSI Common library [LibCommon]. Due to the concepts within LibCommon synchronization does not take place directly between connected SIP components but via a synchronization server component. Sample configurations are provided in the following figure. For further details on the synchronization please refer to <http://www.ttcn-3.org/index.php/development/devlibraries/devlib-libcommon>

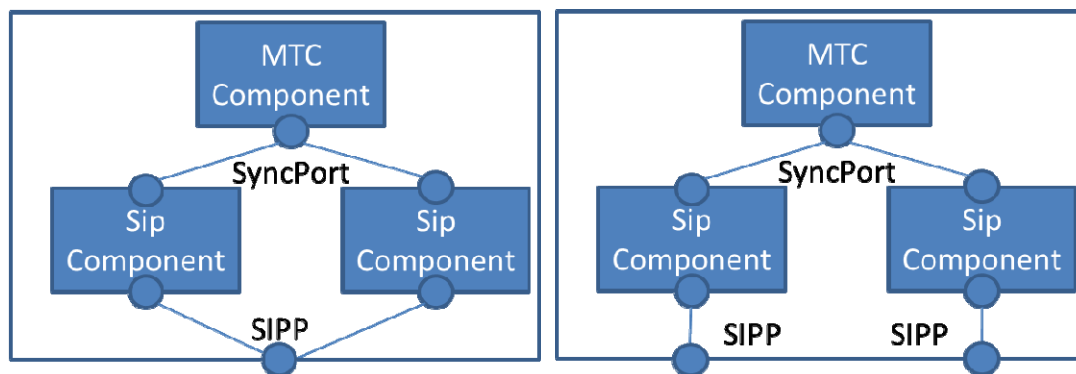


Figure 3: Sample configurations using several SIP components

LibSip version 3 is designed for import into a larger TTCN-3 library, e.g. for IMS test suites [LibImS]. The current version 3 of LibImS is based on the LibSip version 3 library. It extends the LibSipV3 component and reuses related TTCN-3 definitions:

```

type component ImsComponent extends SipComponent {
  // general variables
  var ImsInterfaceProfile vc_interfaceprofile;
} // end ImsComponent

```

5.4 Further details

LibSipV3 includes six external functions that need to be provided by a platform adapter.

Table 3: External functions within LibSipV3

External function	Description
fx_calculateDigestResponse	function declared in LibSip_Steps External function to generate a digest response.
fx_calculateXMLBodyLen	function declared in LibSip_Templates Declaration of external functions to calculate length of message bodies switching of internal or external functions are made by boolean module parameter/PIXIT USE_FX_FOR_XML_LENGTH declared at top of this module
fx_getIpAddr	function declared in LibSip_Steps External function to get IP address.
fx_GetSC_TimeStamp	function declared in LibSip_SMSFunctions
fx_putInLowercase	function declared in LibSip_Steps External function to return the equivalent string in lower case
fx_rndStr	function declared in LibSip_Steps External function to return random charstring

Furthermore 19 module parameters may be considered to modify timeout values, to change predefined SDP parameters and /or other SIP protocol characteristics (see table 4).

Table 4: Module parameter within LibSipV3

Module Parameter Name	Description
PX_SIP_SDP_USER_NAME	charstring for SDP user name
PX_SIP_SDP_SESSION_ID	charstring for SDP session identifier
PX_SIP_SDP_DYN	charstring for SDP dynamic port
PX_SIP_SDP_B_MODIFIER	charstring for SDP bandwidth modifier
PX_SIP_SDP_B_BANDWIDTH	integer for SDP bandwidth value
PX_SIP_SDP_ENCODING	charstring for SDP media attribute encoding supported by the IUT
PX_SIP_SDP_CLOCKRATE	charstring for SDP media attribute encoding clock rate supported by the IUT
PX_MB_LENGTH_FROM_ENCVAL	boolean for MessageBody length calculation based on encvalue operation result
PX_USE_FX_FOR_XML_LENGTH	boolean for MessageBody length calculation to be performed by external function
PX_SIP_TRANSPORT	charstring for Used Transport in upper case "UDP"/"TCP"
PX_SIP_REGISTRATION	boolean for the SIP user if it have to register itself before executing a test case
PX_AUTH_ALGORITHM	charstring for PX_AUTH_ALGORITHM security algorithm Possible values: MD5 or AKAv1-MD5
PX_SIP_REGISTER_AUTHENTICATION_ENABLED	boolean for option controlling if authentication is enabled/disabled for REGISTER messages
PX_SIP_INVITE_AUTHENTICATION_ENABLED	boolean for option controlling if authentication is enabled/disabled for INVITE messages
PX_SIP_TWAIT	float for TWait default value for waiting an operator action
PX_SIP_TACK	float for Tack default value for waiting an acknowledgement

Module Parameter Name	Description
PX_SIP_TRESP	float for TResp default value for waiting for a response from the IUT
PX_SIP_TNOACT	float for TNoAct default value for waiting no message from the IUT Value given for PX_TNOACT should be less than value of SHORT_REGISTRATION constant (which is currently "3" (seconds))
PX_SIP_MIME_BOUNDARY	charstring for delimiter value used in mime multipart message to separate message body parts

LibSip currently supports data type (SIP headers) that are based/defined in the following standards:

- IETF RFC 3261 [i.3]: SIP: Session Initiation Protocol
- IETF RFC 3262 [i.22]: Reliability of Provisional Responses in the Session Initiation Protocol (SIP)
- IETF RFC 3265 [i.23]: Session Initiation Protocol (SIP)-Specific Event Notification
- IETF RFC 3313 [i.24]: Private Session Initiation Protocol (SIP) Extensions for Media Authorization
- IETF RFC 3323 [i.25]: A Privacy Mechanism for the Session Initiation Protocol (SIP)
- IETF RFC 3325 [i.26]: Private Extensions to the Session Initiation Protocol (SIP) for Asserted Identity within Trusted Networks
- IETF RFC 3326 [i.27]: The Reason Header Field for the Session Initiation Protocol (SIP)
- IETF RFC 3327 [i.28]: Session Initiation Protocol (SIP) Extension Header Field for Registering Non-Adjacent Contacts
- IETF RFC 3329 [i.29]: Security Mechanism Agreement for the Session Initiation Protocol (SIP)
- IETF RFC 3455 [i.30]: Private Header (P-Header) Extensions to the Session Initiation Protocol (SIP) for the 3rd-Generation Partnership Project (3GPP)
- IETF RFC 3515 [i.31]: The Session Initiation Protocol (SIP) Refer Method
- IETF RFC 3608 [i.32]: Session Initiation Protocol (SIP) Extension Header Field for Service Route Discovery During Registration
- IETF RFC 3841 [i.33]: Caller Preferences for the Session Initiation Protocol (SIP)
- IETF RFC 3891 [i.34]: The Session Initiation Protocol (SIP) "Replaces" Header
- IETF RFC 3892 [i.35]: The Session Initiation Protocol (SIP) Referred-By Mechanism
- IETF RFC 4028 [i.36]: Session Timers in the Session Initiation Protocol (SIP)
- IETF RFC 4244 [i.37]: An Extension to the Session Initiation Protocol (SIP) for Request History Information
- IETF RFC 4488 [i.38]: Suppression of Session Initiation Protocol (SIP) REFER Method Implicit Subscription
- IETF RFC 5009 [i.39] Private Header (P-Header) Extension to the Session Initiation Protocol (SIP) for Authorization of Early Media
- IETF RFC 6442 [i.40]: Location Conveyance for the Session Initiation Protocol
- draft-johnston-sipping-cc-uu [i.41]: Transporting User to User Call Control Information in SIP for ISDN Interworking [used in historical test suites]

LibImS is extending LibSip to cover IMS specific aspects as defined in:

- ETSI TS 124 229 [i.2]: IP multimedia call control protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP); Stage 3

- IETF RFC 2617 [i.42]: HTTP Authentication: Basic and Digest Access Authentication
- IETF RFC 5031 [i.43]: A Uniform Resource Name (URN) for and Other Well-Known Services

5.5 Summary of changes

Work started from LibSip/LibImS version 2 and included the following changes:

- Merged input and considered change requests from STF467 and STF160
- Cleaned up code by removing duplicated code, obsolete comments and TODOs
- Reduction of PIXITS: ATS specific PIXITS removed and replaced by parameters
- Applied template restrictions for global templates and template parameters
- Hardcoded values moved to constants, PIXIT and parameters
- Reduced warnings
- Applied common formatting
- Updated headers and T3Doc comments
- Fixed issues identified by T3Q

The actual sources of LibSip and LibImS are available online at the ETSI WebSVN <http://forge.etsi.org/websvn/>.

Annex A: History of the LibSip and LibImS sources

The following list shows the STFs using and extending the LibSip and LibImS libraries and names the TTCN-3 test specifications for which the libraries form the core part of their TTCN-3 code:

- STF366 on interworking testing
ETSI TS 186 009-3 [i.4]: IMS-ISUP interworking
- STFs 368 and 406 on supplementary service testing
ETSI TS 186 005-3 [i.5]: Terminating Identity Presentation/ Terminating Identity Restriction
ETSI TS 186 007-3 [i.6]: Communication Hold
ETSI TS 186 010-3 [i.7]: Conference
ETSI TS 186 014-3 [i.8]: Communication Diversion
ETSI TS 186 016-3 [i.9]: Closed User Group
ETSI TS 186 017-3 [i.10]: Anonymous Communication Rejection-Communication Barring
ETSI TS 186 018-3 [i.11]: Malicious Communication Identification
ETSI TS 186 022-3 [i.12]: Communication Waiting
ETSI TS 102 890-3 [i.13]: Message Waiting Indication
- STF369 on network integration testing
ETSI TS 186 001-4 [i.14]: IMS-IMS end-to-end testing
- STFs 370, 407 and 435 on support software for IMS plugtests
ETSI TS 186 011-3 [i.15]: Conformance criteria checker for NNI interoperability
- STFs 434, 443 and 450 on diameter testing
ETSI TS 101 580-3 [i.16]: Rx interface, SIP used as trigger protocol
ETSI TS 101 606-3 [i.17]: Gx interface
- STF445 on basic call testing
ETSI TS 102 790-3 [i.18]: IMS basic call, update to 3GPP Release 10

It should also be noted that STF160 which is responsible for the development of the all conformance test specifications for mobile devices is using the libraries' type systems very extensively for their work.

After the development of the initial version of the TTCN-3 libraries LibSip and LibImS all the above mentioned STFs continued working on the libraries to add features that were individually needed for each of the STFs but were still seen as sufficiently generic to be added to a library. None of those STFs had a specific budget to maintain the TTCN-3 libraries and the additions/modifications were mainly done "on the fly" as required by the conformance test case under production. This sometimes led to suboptimal solutions ("quick fixes"), duplication of TTCN-3 structures and in general to an inhomogeneous application of ETSI's naming and coding rules. After five years of extensive use of the LibSip and LibImS they need to be overhauled to continue being a fit tool for future STFs on the development of conformance test cases in the technical area of LTE, EPC and IMS.

A further aspect is the development of the TTCN-3 standard itself. In April 2008, at the start of STF346 the TTCN-3 standard ETSI ES 201 873-1 [i.1] had just been published in its version V3.3.2. In its present version of June 2014 it is published as V4.6.1. Between those two versions lie six further publications each of them adding significant more and more advanced feature to the TTCN-3 notation. Lifting the LibSip and LibImS libraries to the latest TTCN-3 related state-of-the-art is the keystone for future usability of the libraries in the most efficient way.

History

Document history		
V1.1.1	November 2014	Publication