The INTOOL/CATG European project: development of an industrial tool in the field of Computer Aided Test Generation

Etienne Desécures

Sema Group

56, rue Roger Salengro - 94126 Fontenay-sous-Bois Cedex, France

Tel: +33 1 43 94 58 37 E-mail: Etienne.Desecures@sema-taa.fr

Laurent Boullier

France Télécom - CNET

Technopole Anticipa - 22307 Lannion Cedex, France

Tel: +33 2 96 05 25 17 E-mail: laurent.boullier@lannion.cnet.fr

Bernard Péquignot

Clemessy

18, rue de Thann - B.P. 2499 - 68057 Mulhouse Cedex, France

Tel: +33 3 89 32 32 32 E-mail: b.pequignot@clemessy.fr

Abstract

This paper presents the work and the results of the INTOOL/CATG project, initiated by the EC to provide tools in the field of Computer Aided Test Generation of TTCN test suites. After a survey of potential users' expectation, a tool has been developed and integrated in a complete test design factory covering several aspects of the test life-cycle from SDL editing to ATS completion and maintenance. The technical approach is based on the generation principles of TVEDA, a prototype developed by France Télécom, and on the use of efficient software components. Validation experiments have been carried out and have addressed ISDN and TETRA protocols.

Keywords

Conformance testing, generation of test suites, traceability, SDL, ASN.1, TTCN

1 INTRODUCTION

The INTOOL/CATG (Computer Aided Test Generation) project has been launched in the framework of the "INFRASTRUCTURAL TOOLS" programme of the European Commission. This programme aimed at developing tools to meet the

following objectives:

- improve the quality of test system components,
- speed up and reduce the cost of global test services development,
- facilitate the setting of Conformance Testing Services in Information Technology and Telecommunications.

Apart from CATG, the INTOOL programme includes two other projects: **Generic Compilers and Interpreters** (definition of an architecture to ensure independence of TTCN compilers against test tools) and **Open Test Environment** (definition of a standardised architecture and process for conformance test tools).

The goal of the INTOOL/CATG project was to provide a tool achieving automatic test suite generation from protocol specifications available in SDL. The technical approach which has been selected after a call for participation from the European Commission, is based on the industrialisation of the TVEDA prototype (see [6]) which has been developed by France Télécom - CNET. The project aimed also to investigate to which domains the tool is applicable.

The selected consortium includes various complementary expertise and contributions from the following companies: Sema Group, France Télécom CNET, Clemessy, Alcatel Titn Answare, Alcatel Switzerland, Sema Group Telecom and Siemens. Supervision of the INTOOL programme has been assigned to EOTC, the European Organisation for Testing and Certification.

2 FUNCTIONALITIES DEFINITION

Basic tool features

The test generation technique to be implemented in TTCN Maker corresponds to the technique developed for TVEDA. Support of the last versions of the languages, that is to say SDL92 and TTCN edition 2, is an evident requirement for an industrial tool. Operational properties, such as independence from any other TTCN tool, and ability to process real-life cases, which implies high execution speed and efficient memory management, have also been defined at this step. In addition, within the limits allowed by the resources of the project, some freedom was left to provide additional features according to the needs of potential users.

Identification of possible improvements according to users' needs.

In order to evaluate which precise features could be included in TTCN Maker, a detail review of the features which were available in TVEDA has been made, together with a review of the features which could be added. Sixteen potential improvements listed in table 1 have been identified. In order to make requirement choices in accordance with the users' needs, the project has prepared a questionnaire and carried on a survey among the potential users of TTCN Maker, i.e. a fairly large number of companies and institutions involved in telecommunication testing.

The questionnaire was divided into three parts: 1) who are the users, 2) what is their general background in the field of testing, and what are their general needs in terms of software tools, 3) what kind of improvements to the TVEDA prototype

they would suggest for TTCN Maker.

The consortium has received 17 answers, the majority of which comes from Specification, Development and Qualification people. According to the responses, it appears that this tool should be able to have complete SDL as input and should be able to generate a complete TTCN ATS with ASN.1 descriptions. The tool has to be provided with a methodological guide and additional functions to select the SDL parts that have to be tested, to structure the test suite and to show the testing architecture. The improvements that have been selected to be implemented in TTCN Maker appears in normal style. The selection took into account the priorities expressed by the responders, the technical feasibility and the budget constraints.

Table 1 Improvements against TVEDA definition.

Considered as important by users	Considered as less important
Produce ASN.1 constraint tables	Coverage evaluation tool
Produce TTCN declaration parts	Traceability links from tests to spec.
TTCN compliant to ETSI style guide	<i>Accept GDMO input</i>
Take into account ASN.1 data types	<i>Take into account other SDL constructs</i>
Provide a methodological guide	<i>Remove dynamic process restriction</i>
Develop a user friendly interface	<i>Take into account abstract data types</i>
<i>Remove SDL single process restriction</i>	
<i>Produce complete TTCN test steps</i>	
<i>Produce concurrent TTCN</i>	
More complete TTCN constraints	

3 TOOL FEATURES

As shown by figure 1 presenting TTCN Maker architecture at high level, two versions of the tool have been developed: a stand-alone version, completely independent from any other tool, and a version integrated in a complete test design factory.

Implemented functionalities for the standalone version

The standalone version, invoked through a Unix command line, processes a specification complying with the Z.105 recommendation (SDL combined with ASN.1). From a syntactic point of view the whole Z.105 definition is supported. Nevertheless a good result depends on the semantic correctness of the specification and the conformity to constraints detailed in the user manual of the tool. Moreover, ASN.1 data types and their corresponding values are interpreted. The generation is piloted by a parameter file containing a list of parameters and their values enabling to define the IUT control on the tester, EFSM transformations, and the form of the ATS.

Each ATS produced by TTCN Maker is composed of:

- a Test Suite Overview consistent with the dynamic part,
- a complete declarations part,
- a constraints part to be reviewed,
- a dynamic part containing test cases, test steps and defaults. Test steps are generated empty.

Declarations and constraints are expressed in ASN.1. The format of the generated ATS is TTCN.MP compliant to the delivery 8.4 of TTCN edition 2.

In addition to the ATS, TTCN Maker produces a report file. This report obeys a precise syntax which enables its post-processing by external tools, e.g. test coverage and traceability tools, and contains information related to the generation (generation parameters, errors and warnings, textual cross-reference from the generated ATS to the source SDL).

Figure 1 TTCN Maker architecture.

Implemented functionalities for the integrated version

The version of TTCN Maker integrated to Concerto differs from the stand-alone version on the following points:

- selection of the SDL input file and selection of the parameters through a simple graphical user interface,
- TTCN ATS stored in the Concerto/TTCN database,
- on-line help available.

In addition, when coupled with the Geode SDL editor, TTCN Maker enables to select the SDL process to be tested directly in Geode, and sets hypertext links from the generated test cases to the corresponding transitions. Figure 2 gives a simple example of an SDL branch displayed with the GEODE editor and the test case automatically derived from this transition by TTCN Maker, and displayed with the Concerto/TTCN editor. Notice the automatically produced test purpose and comments parts, and the hypertext link attached to the test purpose.

Figure 2 Highlighted transition in Geode and test case in Concerto/TTCN.

4 GENERATION METHOD

Inspired from TVEDA, TTCN Maker is based on a syntactic technique which produces test cases by a simple syntactic transformation of the specification. In this technique, emphasis is put on heuristics which allow an automatic computation of the test purposes.

Constraints on the SDL

The syntactic technique puts some constraints on the SDL constructs which can be handled by the tool. These constraints are of two kinds:

- restrictions on SDL constructs. The tool ignores several constructs.
- restrictions on SDL style. The syntactic technique generates test cases for a single SDL process. Therefore the tool cannot compute the combined behaviour of several processes.

Test purposes

One of the main features of TTCN Maker, is the automatic computation of the test purposes. For doing this, the tool incorporates some heuristics, based on the syntactic structure of the SDL specification. Basically, one test case is produced in order to check each branch of the SDL. This basic test selection mechanism can be modified by the user of TTCN Maker in the following ways:

- restrict the part of the specification that is tested: choice of states, input signals, etc.
 - enumerate data values which appear in the SDL branches: test several values of parameters on input signals, or on the contrary merge test cases corresponding to several branches if the observable behaviour is the same in these branches, etc.
- These heuristics have been defined after observation of the strategy used by human experts in order to define the test cases.

Test generation process

Once the test purposes have been selected, TTCN Maker computes the behaviour of the test cases. This is done in several steps.

Step 1: Analysis of the SDL specification, and computation of an abstract extended finite state machine (EFSM). During this step, the test architecture is taken into account. The level of abstraction at which the specification is tested can be influenced, through the decision to "control" or not variables or signals.

Step 2: Production of test cases in an internal abstract format. Test cases are produced, which have the following structure:

- call to a preamble which brings the IUT into the start state of the tested transition.
- send and receive events corresponding to the tested transitions. At this level, non determinism is taken into account. Non determinism can result from uncontrolled variables or from uncontrolled events. Constraints are also produced in an incomplete way, using heuristics where possible.
- call to a check sequence which is supposed to check the final state of the tested transition and bring back the IUT in its initial state.

Step 3: Formatting of TTCN suite. The test suite is produced in TTCN according to the *ad hoc* generation parameters. This includes computation of the test suite structure and production of the different TTCN parts.

5 EXPERIMENTS

Numerous experiments performed by CNET with the TVEDA prototype and mentioned in [5] have shown that the TTCN Maker method is particularly suited for protocols up to level 4 of the OSI model. In addition two main experiments were conducted within the INTOOL/CATG project to give an assessment on TTCN Maker itself: an experiment on a part of the TETRA specification developed by ETSI, and an experiment on Q2931 (Broadband ISDN).

The purpose of the Q2931 experiment, performed by Clemessy, was to give an evaluation of the TTCN Maker tool by using it to generate a complete executable test suite. The experiment focused particularly on the work necessary to complete the test suite generated with TTCN Maker to be able to run it. The tested protocol was the L3AS protocol Q2931 Network Side, developed in the RACE 2 / TRIBUNE project and compliant with ATM Forum V3.1. This protocol has been specified in SDL by KPN Research-Netherlands and implemented by Clemessy with the Geode tool by Verilog. The ATS generated by TTCN Maker has been compared to an already existing ATS for the same protocol, supplied by KPN. After manual completion the ATS has been successfully compiled. The tester is the C-BIT, a tool developed by Clemessy running on Sun workstations.

This experiment has shown that by generating a complete skeleton of an ATS, with detailed test purposes, TTCN Maker simplifies the work of the test developer:

- The tedious tasks like defining the PDUs, the ASPs, the PCOs or the Timers are achieved automatically by the tool.
- The generation of the dynamic part of the ATS and of a basic constraint for each ASP and PDU allows the developer to concentrate on his most important work : the completion of the constraints and test steps (based on the generated test purposes and on his test objectives) which determines the efficiency of his test suite.

6 CONCLUSION

The experiments have shown that TTCN Maker reached the following results:

- fast generation of test suite skeletons, including message and data type declaration, test purpose creation, test and default behaviours, etc.,
- reducing the time necessary to create a test suite even if an SDL model is not previously available,
- high level of performance due to the syntactic method, whereas simulation techniques often face memory problems because of the so-called "state-explosion" problem,
- high level of parameterisation in order to capture user experience and add it to the benefit of using automated test suite production,
- available either as a completely independent software, or integrated within a test design factory,
- being one of the very first tools accepting Z105 specification including ASN.1, allowing to use SDL specification where the data type declaration is the same as the actual protocol specification, thus producing correct type definition in the ATS.

Nevertheless further useful improvements addressing more complete generation and full processing of the SDL can be performed. In parallel to the INTOOL/CATG project, conclusive research studies based on the connection of TVEDA and SDL verification techniques have been done by France Télécom - CNET (see [7]). This gives the direction for the next versions of the tool.

7 REFERENCES

- [1] CCITT, Recommendation Z100: Specification and Description Language.
- [2] ITU-T Standardization Sector, Z105 Recommendation.
- [3] ISO/IEC 9646-3 (1992): "Information technology - Open systems interconnection - Conformance testing methodology and framework - Part 3: The Tree and Tabular Combined Notation".
- [4] ETR 141: Methods for Testing and Specification (MTS); Protocol and profile conformance testing specifications; The TTCN style guide.
- [5] E. André, B. Baumgarten, A. Cavalli, M. Gill, O. Henniger, R. Kuhn and R. Lai, Application of Testing Methodologies in Industry - Minutes of the IWTCs'96 Panel Discussion, GMD, December 1996.
- [6] L. Doldi, V. Encontre, J.-C. Fernandez, T. Jéron, S. Le Bricquie, N. Texier, and M. Phalippou (1996) Assessment of automatic generation methods of conformance test suites in an industrial context, in *Testing of Communicating Systems* (proceedings of IWTCs'96).
- [7] M. Clatin, R. Groz, M. Phalippou and R. Thummel, Two approaches linking a test generation tool with verification techniques, in *Conference proceedings of IWPTS'95*.