

# Case Study

## Using TTCN-3 and TWorkbench to Assist Functional and Regression Testing of a Financial Data Warehouse System for an International Bank

### Introduction

Testing of a financial data warehouse system typically involves over 100 separate process steps. To perform tests manually can be time-consuming, error prone and presents a high learning curve to test analysts new to the system. Major upgrades to a system typically involve several weeks of functional testing. Minor releases focus on functional testing of enhancements, and quite often release schedules do not allow for full manual regression testing.

A pilot study was conducted over a period of 3 months to investigate the feasibility of using TTCN-3 and a suitable software package to improve accuracy and efficiency of the functional and regression testing of a financial data warehouse. Additional objectives were to standardize the testing process and to reduce the learning curve of test analysts new to the system.

Following the successful completion of the pilot study, TWorkbench was selected as a suitable software package and over the next 5 months was used to assist functional testing of new releases and to implement regression testing on existing systems.

This work is still ongoing, but the benefits have been immediately noticeable and there are plans to develop further test scripts to assist in the automation performance testing and shakedowns of new environments using TTCN-3.

### TTCN-3 Application Scenario

TTCN-3 was used primarily as a control program to start various test scripts. The TTCN-3 test cases consisted of calls to a test adapter which issued windows command lines. These windows command lines called test scripts which used third party and custom built software to perform various tasks, such as:

- Check if the SUT is setup correctly (software running, databases running etc.)
- FTP test data to specified servers
- Calls to batch scheduling programs to load data, start general ledger processes etc.
- Calls to various UNIX scripts to load data, produce reports etc.
- Calls to various SQL scripts to prepare the database of the SUT
- Calls to various custom developed test tools to extract data at various stages in the test cycle and to compare it to the expected results

The test scripts then communicated success/failure/error messages back to the TTCN-3 test cases. The TTCN-3 control module contained logic to determine the next step of the test and to log the results in a test report.

### Advantages of TTCN-3

Many of the test analysts in a financial environment are recruited primarily for their business knowledge, although it is common to have experience with high level languages. The TTCN-3 language proved to be easy to program, and following the pilot study which created the basic building blocks for the test suites, many of our analysts were creating their own test suites within days.

The use of a standardized test language ensures that we are not limited to the proprietary language of a specific vendor. TTCN-3 consists of language features such as parameterization, running of parallel test cases, timing ability, logging ability, or the ability to logically order test cases and control decisions on which test cases to run next. This allowed us to run the test suite overnight simultaneously for several source systems, dramatically reducing the regression test cycle time ...

... TTCN-3 has proved suitable for gradual implementation of an automated test suite: In the first phase we have used it primarily as a test control module, responsible for running existing test tools and recording responses from these test tools. This means we can re-use the functionality in existing tools.

## Why the Bank Selected TWorkbench

Software from several TTCN-3 vendors was examined during the pilot phase, and TWorkbench Basic was selected for the following reasons:

It offers an integrated development and test suite management environment that is easy to setup and use and can be installed on a single machine or on a server. Some of the other packages examined consisted of several discrete components (editor, execution manager etc.) which were deemed less user friendly. Other packages involved installing software on both client and server machines, which seemed more suitable for telecoms applications in testing of remote distributed applications.

A strategic decision was made to avoid in-house programming of the test adaptor required (which requires Java or C++ skills) and to focus our test analysts on producing the high level TTCN-3 test cases, a language which was more suitable to their skills.

Testing Technologies provided us with a stable test adaptor which is suitable for our needs, and we do not yet anticipate the need to improve it. The level of technical support from Testing Technologies during the pilot phase and since then has always been friendly, helpful and with a quick response time.

We found the Testing Technologies account manager to be helpful in providing a package of development and execution licenses to meet our needs and flexible in ensuring we had no down time in development during the software approval and purchase process.



Bas Wieman, Test Manager, International Bank

"Where most (GUI oriented) test automation tools stop, TTCN-3 starts. This is the case for us in a back office, batch driven architecture with a data warehouse. TTCN-3 enables us to easily automate a multitude of manual steps surrounding the batch process under test.

TTCN-3 is also very easy to adopt as long as you have a basic understanding of any programming or scripting language. The fact that it is a standardized language ensures that you are not limited to the proprietary language of a specific vendor. The pro active support during our pilot project made us choose TWorkbench as our test automation tool."



# Case Study

## Testing SIP Signaling Compliance with TTCN-3 Tools of Testing Technologies

### Company Description

VeriSign operates the systems that manage .com and .net, handling as many as 21-billion Web and email look-ups every day.

VeriSign runs one of the largest telecommunications signaling networks in the world, enabling services such as cellular roaming, text messaging, caller ID, multimedia messaging, and mobile media management. VeriSign also provides managed security services, security consulting, strong authentication solutions, anti-phishing services and commerce security services to organizations all over the world - and secures over 700,000 Web servers worldwide.

By leveraging its world-class infrastructure and robust platform set to deliver services in a managed services business model, VeriSign's intelligent infrastructure services provide customers with unmatched operational efficiencies, increased intelligence, and greater visibility into key data trends that drive their business.

As next-generation networks emerge, VeriSign deploys the intelligent infrastructure services necessary for everything from RFID-enabled supply chains, to inter-enterprise voice-over-Internet Protocol (VoIP), to the seamless delivery of mobile content.

### Project Description

VeriSign has developed a SIP and ENUM-based centralized routing directory, called VeriSign® Network Routing Directory (NRD). This engine is based on VeriSign's Advanced Transaction Lookup And Signaling (ATLASSM) platform – the same platform that runs the .com/.net registries on the internet.

The NRD is logically layered upon a service provider's core network as a registry that enables the centralization of inter- and intra-domain route discovery. NRD may function as a common interconnect registry and as a central routing server to discover the location of endpoints.

Equipped with SIP and ENUM interfaces, the NRD is capable of simultaneously functioning as a SIP Proxy Server, Redirect Server or SIP/ENUM Registry. Through callouts to network elements, both internal and external to the core network, NRD supports interoperability between the SIP and ENUM protocols.

Testing Technologies provided VeriSign with a solution for testing protocol compliance of the NRD product that includes SIP standards. This solution contains a fully standardized conformance test suite with over 600 ready-to-use test cases.

### Requirements on a Test Tool

VeriSign needed a solution that enables test development and execution within one test tool.

This tool had to be robust, flexible and extensible. It had to provide support for the protocols VeriSign desired immediately, but also had to be capable of integrating other protocols with little effort in the future. This tool had definitely to be user-friendly to ensure fast and easy handling.

## Reasons for Choosing Tools of Testing Technologies

We selected Testing Tech's all-in-one tools, as they met most of our requirements while using an industry standard language (TTCN-3). That greatly eases the learning curve for anyone beginning to use this product.

The tools are delivered with an extensive set of pre-built test cases, a TTCN-3 compiler and an easy to use GUI. Additionally, the tools support the protocols we were initially interested in (SIP over UDP and TCP), and Testing Tech indicated that their roadmap included other protocols which we would need in the future – such as new transport stacks like TCP/TLS for SIP, TCAP, IS41/MAP and SIGTRAN.

## Kinds of Systems Tested

VeriSign is utilizing the Testing Tech tools to test our own home-grown SIP stack with a focus towards testing SIP Proxy and Redirect server functionality.

## Inhouse Creation of Test Cases

At this point, VeriSign has utilized the GFT Editor for viewing the pre-built test cases. As the test suite provided by Testing Tech was quite exhaustive, we have not felt the need to supplement this with our own test cases. As soon as we extend our system (IUT) we might be approaching the possibility to prepare new test case skeletons in TTCN-3 using the development editor (CL Editor) of TTworbench.

## Testing Technologies' Reaction Time, Support and Quality

One of the biggest pain points with any new protocol is the ability of a vendor to quickly understand and acknowledge the problem being reported and to provide a fast solution to it. With a bleeding edge protocol such as SIP, this problem is further compounded by the fact that the definition and interpretation of the protocol widely varies.

On these fronts, VeriSign's experience in dealing with Testing Tech has been very positive. During the initial phase of usage of the toolset, the support from Testing Tech was very good and questions to the support mailing list were answered very quickly. Support personnel from Testing Tech, such as Dirk Borowski, were pleasant to deal with, their understanding of the protocol was thorough, and they were eager to help us using the tool. Not only this, we also received example cases for new SIP methods concerning IMS.

As could be expected from any new product, there were teething troubles – the very first release VeriSign received had some java/eclipse related performance, compilation time and memory issues. Testing Tech has been very responsive to these issues and they turned around with patches and workarounds to help resolve these issues within a short timeframe.

## Future Plans

SIP Protocol Engine on VeriSign's NRD product already supports UDP and TCP as the transport protocols. In the future, we will use Testing Tech's provided TLS support in the toolset of TTworbench. Another protocol we are considering is TCAP. For this, we are also looking to integrate with SIGTRAN at the transport layer.



# Case Study

## Using TTCN-3 and TWorkbench for Automation of System and Component Testing of the R&S *ACCESSNET*<sup>®</sup>-T TETRA Network

### Company Description

As established specialist for mobile communication technology and strong member of the Rohde & Schwarz group of companies, R&S BICK Mobilfunk has been a trend-setter for professional digital radio networks for many years. Right from its foundation, R&S BICK Mobilfunk has started playing a competent and active role in the development of the TETRA standard by working together with ETSI. R&S BICK has considerably influenced the implementation of user friendly and state-of-the-art radio communication solutions.

Expanding its leading position in the world market R&S BICK Mobilfunk has also developed sophisticated customized solutions in digital TETRA networks: for public transport companies, public safety organisations, for multiple industries, as also for airport networks, and oil or gas related enterprises.

R&S BICK's core product is the *ACCESSNET*<sup>®</sup>-T TETRA network solution, which – as a terminal supplier independent system – intensely supports the multi vendor principle by fully complying with the open European TETRA standards. But also a constantly growing number of applications worldwide harmonize with the *ACCESSNET*<sup>®</sup>-T system infrastructure. Especially the integration of applications via its common application interface *A-CAPI*<sup>®</sup> is promoted by the Rohde & Schwarz *ACCESSNET*<sup>®</sup>-T TETRA Application Partner Program *A-TAPP*<sup>®</sup>.

### Project Description

The main test suite performs tests by operating TETRA handsets and mobiles via the Peripheral Equipment Interface (PEI), a TETRA enhanced AT command set, in clear or encrypted mode. The *ACCESSNET*<sup>®</sup>-T network is stimulated by setting up voice calls, sending SDS and status messages or transmitting circuit mode data. Channels can be blocked automatically by executing SNMP commands to verify queuing scenarios. Other test suites test only specific system components or -interfaces like the *A-CAPI*<sup>®</sup>, which is used for example by dispatcher applications.

### Requirements on a Test Language and Tool

R&S BICK Mobilfunk did require a tool to run automated system and component tests of its primary product, the *ACCESSNET*<sup>®</sup>-T TETRA network, to reduce time consuming and repetitive manual tests. Expecting thousands of test cases to be created, R&S BICK needed a stable and future-proof solution, which was perfectly met by using TTCN-3 as the only test language standardized by ETSI.

TTCN-3 has been designed specifically for testing protocol based status machines, i.e. reactive systems, like the protocol stacks of today's digital mobile networks. When using a common scripting language one usually has to provide a message system, blocking states, etc. on a do-it-yourself basis – basic elements already provided by TTCN-3! So TTCN-3 was our first choice considering the testing language.

### Reasons for Choosing Tools of Testing Technologies

The decision to use TWorkbench as TTCN-3 tool resulted from a thorough and extensive evaluation of the Rohde & Schwarz test equipment department at Munich and R&S BICK Mobilfunk.

While R&S Munich's interest was on an adaptable and extendable platform for integrated protocol testers, we valued the flexibility of a PC based TTCN-3 tool running on either Windows or Linux. The richness of the Eclipse based IDE and GUI was quite compelling in contrast to other tools taken into regard ...

... Concerns about a lack of performance of a JAVA based test system have been reduced quickly, since Testing Technologies' development team has managed to improve the performance of TTworkbench constantly. The release of version 1.1.1, that highlighted a leap in performance, convinced R&S BICK to use TTworkbench for load, performance and long-term tests as well.

TTworkbench provides a test designer and -executor with all imaginable test automation tools (e.g. an MSC based editor or a message wizard for creating templates) in one integrated test environment. Also, Testing Technologies proved to be open-minded for ideas regarding the further improvement of TTworkbench.

We have found TTworkbench to be the perfect solution to meet our requirements for running automated system tests, preferably at nighttime, to reduce the daily burden of endless manual testing.

## Kinds of Systems Tested

R&S BICK is testing TETRA network elements on a system and component test level either directly by e.g. network connections or via air interface by controlling TETRA mobiles and handsets.

As the system is being stimulated via several interfaces using various connections and protocols like TCP, UDP, serial COM, GPIB, etc., the test adapters and e.g. codecs for proprietary message formats had to be implemented before writing any test cases. But the JAVA language, which TTworkbench and the generated code are based on, turned out to be easy to learn. The reference designs, provided by Testing Technologies, have been very useful for creating test adapters and codecs on our own.

## Inhouse Creation of Test Cases and Future Plans

Since there are currently no TTCN-3 test cases available for TETRA from ETSI, R&S BICK had to create its own test cases, which turned out to be easy-going once the test adapter and codec framework was set up. After participating in the three day TTCN-3 Tutorial at Testing Technologies' in Berlin, our team had a good start getting into TTCN-3 business.

Future plans of R&S BICK Mobilfunk include cell re-selection tests by operating GPIB controlled RF attenuators and additional system components.

## Testing Technologies' Reaction Time, Support and Quality

In most cases, the response time of Testing Technologies' support team has been considerably fast. Solutions or patches are generally provided within days or even hours, seldom later (depending on the complexity of the problem), if not even solved directly by phone.



Michael Dralle, Development and Test Engineer, R&S BICK Mobilfunk GmbH, Germany

"R&S BICK needed a stable and extensible platform for running automated system and component tests of our ACCESSNET®-T TETRA system. TTworkbench turned out to be the perfect solution for our requirements, providing all kinds of test automation features in one integrated test environment. Expecting thousands of test cases to be created, we value this future-proof, PC based TTCN-3 tool with such flexibility, i.e. concerning test interfaces. By running our tests automated, preferably at night time, we expect to clearly reduce the daily burden of manual testing."



# Case Study

## Understanding TTCN-3 Testing Technology and Evaluating Suitability for Non-Communication Domains

### Company Description

Samsung Electronics produces various kinds of electronic devices such as memory, digital TV, printers, mp3 players, notebooks, mobile phones, network devices, home appliances, etc. Just as software is growing in size and complexity, development efforts are increasing tremendously. Recognizing this trend and the related importance of software testing, Samsung is striving to improve test methods and frameworks.

### Project Description

Along with the attempt to improve software quality, Samsung has previously tried various kinds of test scripts. However, due to a high diversity of different test languages scattered across the organization, communication and cooperation between test system developers are becoming increasingly difficult.

Following the interest in harmonizing Samsung's test system, our test managers proposed a unified test solution being used throughout the entire organization. After evaluating different test methods, we have found TTCN-3 suitable to meet this challenging requirement.

Our project aimed at gaining solid knowledge and understanding of TTCN-3 technology and the variety in terms of its application. For a lack of experience with TTCN-3, Samsung decided to found a partnership with Testing Technologies. Three pilot test systems were set up:

- A web service based test system using message-based communication
- A DTV test system using procedure-based communication
- A network base station test system using message-based communication

### Requirements on a Test Tool

Samsung sets a high value on standards-based testing. We needed an all-in-one tool for TTCN-3 editing, compiling and debugging. The Java codec and adapter had to be included in the tool, providing a Java editor, compiler and debugger.

Samsung wanted to purchase a reliable and flexible platform with a complete, integrated test management system to execute written test cases. In order to start using the tool as soon as possible, it had to be comprehensible and user-friendly.

### Reasons for Choosing Tools of Testing Technologies

TTworkbench complies with all requirements Samsung demanded, containing a comprehensive test management with an easy-to-use graphical editor. The availability of basic codecs and adapters saved us a lot of time and effort. Since the Eclipse-based TTCN-3 IDE is easy to extend, it ensures fast access to multiple technologies, which was important to us.

Above all, TTworkbench provides full test automation features saving us further time and costs. Along with a convincing tool, we relied on Testing Technologies' consultancy services to assist us during the initial phase of our project.

## Kinds of Systems Tested

Our Systems under Test (SUTs) consist of various kinds of above mentioned electronic devices with several Implementations under Test (IUTs) according to the test purposes.

In our pilot test systems, we focused on specific layers: For the initial one, a web service system, the IUT was an in-house remote management protocol. It was followed by setting up a DTV test system with the IUT being a user command control. Finally, within a network test system, the IUT is processed by calls between different base stations.

## Inhouse Creation of Test Cases

Prior to engaging consultancy services of Testing Technologies we were only able to understand a few samples of TTCN-3 test cases. We knew how to modify them but did not manage to create new ones for SUTs which use different protocols. Furthermore, we did not exactly understand the test system architecture, codec (TCI), adapter (TRI), etc.

Thanks to Testing Technologies' highly competent consultants, we are now able to design test systems for various kinds of SUTs using different protocols for a huge variety of test purposes.

## Testing Technologies' Reaction Time, Support and Quality

Samsung was extremely satisfied with the fast reaction time to our queries and the high quality of work delivered by Testing Technologies' test experts. They quickly understood our questions, were able to perceive issues from a customer's point of view, thus providing good solutions for all given tasks during the consultancy phase.

## Future Plans

So far we have performed this pilot project and have acquired basic knowledge about TTCN-3 test systems. In this process, TTCN-3 and TWorkbench have proven to be perfectly suitable for our test purposes. We are now going to make our product test systems work in order to achieve best practice in the network domain. In a following phase, we will transfer the technology to an even wider scale of product tests and domains.



Samsung's Software Quality Assurance Group says:

„The challenging task of applying a unified test solution in our entire organization requires a flexible test technology and tool. For this, TTCN-3 and TWorkbench have proven to be perfectly suitable.

Samsung feels confident to successfully harmonize its test system and to achieve a clear improvement of software quality. The excellent consultancy service of Testing Technologies has helped us to quickly understand TTCN-3 and TWorkbench, thus enabling us to manage complex test scenarios on our own.“

# Case Study

## Using TWorkbench at the University of Applied Sciences of the Saarland

### About the University

The University of Applied Sciences in Saarbrücken currently offers 40 well structured degree programs. Students, usually learning in small groups, have access to modern, well-equipped laboratories, lecture halls and seminar rooms. Excellent supervision and close contact to the more than 120 members of the professorial staff are distinctive features of academic life at the university.

The university places considerable emphasis on high-quality, practical teaching that is closely mixed with real social, business and industrial applications. This enables the university to identify the changing needs of today's working environment at an early stage as well as to adapt and modify its teaching curricula accordingly.

### Project Description

At the HTW, testing is hardly being addressed in courses, at most in terms of Unit testing. The master degree program "Computer Science and Communications Engineering" includes in the domain of protocol engineering a lecture about "Formal Methods in Telecommunications" (60 lessons) teaching our students details about ASN.1, MSC, SDL and TTCN-3. This is followed by the course "Software Development for Communication Networks" where students carry out a software project.

At the University of Applied Sciences it is our goal to put theory into practice. So far we have used the ASN.1 compiler of OSS Nokalva and the SDL tool SAFIRE of Solinet but we did not use any tool for protocol testing. Considering the increasing relevance of testing, we are going to focus more on this topic and also to integrate practical exercises.

### Why TWorkbench

Professional development tools are often not suitable for educational purposes as they are designed for experienced developers and for real projects. Therefore I participated in Testing Technologies three day TTCN-3 training course to get an impression of their test automation tool TWorkbench. The tool is easy to handle, conform to the standard, and the integrated Addressbook example is a perfect exercise. TWorkbench turned out to be well suited for our master students, who are used to Eclipse based development environments.

### The Educational License Agreement

The HTW highly appreciates the possibility to use Testing Technologies' software tools free of charge via an educational license. This allows us to offer practice-oriented teaching. Our administration promptly signed the educational license agreement. Communication and processes of contract have been handled by Testing Technologies fast and smoothly.

### Installation

The access to TWorkbench Basic and the installation on a Windows terminal server were easy. It was helpful for the HTW to have a direct contact person at Testing Technologies for the more complex part of licensing. Testing the installation, we realized that only ten instances of TWorkbench were able to run simultaneously.

The advantage of an installation on a terminal server is, that the software needs to be installed only once and not on all PCs of the computer room. Via a Sun Secure Global Desktop the students had access to the software from home or WLAN allowing a comfortable working environment.

## Working with TWorkbench

During the winter semester 2009/2010, 13 students took part in the course. The limitation of having just ten simultaneously running instances of TWorkbench never caused any problems due to working in teams. I reorganized the course and limited the practical part about SDL considerably to enable students to spend one third of the course on protocol testing.

After a general introduction to protocol testing, students started learning concepts of TTCN-3 focusing on test-specific language elements. The exact language elements had to be acquired in self-study. For this purpose they had to build a TTCN-3 module for testing the Addressbook database analogue to the delivered Addressbook example. It was easy to explain TRI and TCI on the basis of the delivered examples with TWorkbench. Finally, several test cases realized in TTCN-3 were drawn manually in GFT format.

## Résumé

TWorkbench is didactically well suited for our students. They showed a great interest in TTCN-3 and would like to go into this topic more intensively. It would be didactically welcome to have the GFT editor integrated into the educational version.

## Our Plans for the Future

Testing and TTCN-3 have been gaining more and more relevance within the past years. Thus, I plan to extend the amount of courses addressing these topics. I would like to continue working with TWorkbench in order to complete classes with practical exercises.

For future teaching we need to develop more basic exercises including the associated test adaptors and system under tests. This could be done within the scope of student projects.



Reinhard Brocks, Professor for Computer Engineering, School of Engineering  
HTW des Saarlandes, Germany

"The HTW really appreciates the opportunity to use Testing Technologies' software tools free of charge via educational licenses. This enables our university to offer a practice-oriented education."



# Case Study

## Creating an Automated Test Platform for a Localization Service

### Company Description

ASTRID is a company establishing, exploiting, maintaining, and expanding the national radio communication network for emergency and security services in Belgium. ASTRID offers users a radio communication system, a paging system as well as systems for computer aided dispatch (CAD).

By establishing a reliable and transparent link between users, ASTRID aims to promote the smooth running of operations and the safety of users in the field, and thus contribute to the safety and protection of the population as a whole.

### Project Description

ASTRID has recently introduced the service 'radio position' enabling users to track the positions of their radios via geo localization applications. The positions of the tracked radios are centralized in a localization server to which the applications are connected. Communication between server and applications happens via the Mobile Location Protocol (MLP).

We felt the need for an automated test platform that would allow us to verify on a regular basis that offered services are still guaranteed. Above this, we also wanted to have the possibility to validate the different geo localization applications before they would be connected to our localization server.

### Requirements on a Test Tool

ASTRID was looking for a flexible test tool capable of behaving as server, client or as interface between client and server. These different test sets needed to be clearly distinguishable and easy to use. We also wanted to automate our tests as much as possible and to have automatic reports of the tests.

### Reasons for Choosing Tools of Testing Technologies

ASTRID knew that Testing Technologies had already implemented automatic test cases for interoperability testing in TETRA networks. After seeing a demo of TWorkbench, we were taken with the tool for its unique features. We figured that the all-in-one editor, compiler, debugger and the executing interface would allow us to work more efficiently.

Another deciding reason was the fact that Testing Technologies confirmed our request to integrate the MLP protocol causing us the convenience to work with only one testing platform.

These benefits together with the advantage to use the ETSI standardized programming language TTCN-3 convinced ASTRID to choose the test automation platform TWorkbench.

## Kinds of Systems Tested

Our team started by testing the localization server. The main purpose was to test the compliance with the MLP protocol. After that, we tested the compliance of the applications and the communication between the application and the localization server.

Another set of tests we ran were the automated test cases for interoperability testing in TETRA. These test cases were provided by Testing Technologies.

## Creation of Test Cases

ASTRID has developed all test cases for the localization service in-house. The framework was provided by Testing Technologies, but we created our own test cases and test campaigns. Even though learning the TTCN-3 programming language took some time, it was worth it, since we will use this knowledge for future projects.

## Testing Technologies' Reaction Time, Support and Quality

ASTRID is very happy with the quality of Testing Technologies' customer care. The helpdesk's reaction times and proposed solutions are fast and accurate. Testing Technologies' support team helped us with problems on various levels: going from issues with the TTCN3 language to finding workarounds to get our test cases working. We feel well cared for.

## Future Plans

Our test cases for the localization project will be adapted in the future either when there is a new version of MLP, when there are new options available in the localization server, or when we want to reproduce a specific behavior. Further on, we will use this platform as an example for future integrations of services on our network.



**ASTRID CLS**

„We are sure that the combination of TWorkbench and TTCN-3 contributed to make this project such a success”, says Els Heyvaert, Radio Networks Coverage and Performance Engineer at ASTRID. 'A mature and powerful technology like TTCN-3 embedded in a sophisticated test automation tool like TWorkbench guarantees performance, durability and extensibility, affording ASTRID many opportunities in future projects.’



# Case Study

## Using TWorkbench in Networking Courses for Graduate Students at Tsinghua University, China

### About the University

Tsinghua University was established in 1911 and has evolved into a comprehensive research university at a breathtaking pace. At present, the university is maintaining 14 schools and 56 departments with faculties in science, engineering, humanities, law, medicine, history, philosophy, economics, management, education and art. The university educates over 25.900 students, including 13.100 undergraduates and 12.800 graduates. As one of China's most renowned universities, Tsinghua has become an important institution for fostering talent and scientific research. The educational philosophy of Tsinghua is to „train students with integrity.“ Among over 120.000 students who have graduated from Tsinghua since its founding are many outstanding scholars, eminent entrepreneurs and great statesmen remembered and respected by their fellow Chinese citizens. More information at [www.tsinghua.edu.cn](http://www.tsinghua.edu.cn).

### Course Description

The graduate course on formal methods in computer networks and protocol engineering covers the whole process of protocol engineering including protocol specification, protocol verification and protocol testing. It also introduces some important formal methods used in protocol engineering e.g. FSM, LTS, SPIN, SDL, and TTCN-3. The course requires student's active participation in the form of presentations and practice-oriented projects. Related commercial or academic tools are to be used by the students in their project works. Protocol testing is the most important part of this course, so it is urgently required to provide respective tools to the students.

### Why TWorkbench

Network protocol testing is one of the crucial research directions in our research group. We have conducted many research projects on protocol testing and TTCN-3. We realized that TTCN-3 is a standard, abstract, powerful and extensible testing language, so we widely use TTCN-3 technology in our research projects. As we know, TWorkbench is one of the most popular commercial software tools of TTCN-3, and we had already checked out its evaluation version before. In our impressions, TWorkbench has a friendly user interface, and is very easy to handle. So we chose TWorkbench to use in our course projects.

### Working with TWorkbench

During the autumn semester 2011/2012 totally 14 students took part in the course. The university applied an educational license of TWorkbench Basic for free use of six months. We established a license server that enabled 20 users to work with the test automation platform simultaneously. This way, students could use the software in their homes or dormitories, sparing them the way to lab.

It took about half of the course to introduce theories of protocol testing. After teaching the basics of protocol testing for two classes (one class equals about two hours), students were introduced to basic concepts of TTCN-3. They dealt with the design of TTCN-3 test systems and illustrated how to perform TTCN-3 based testing with an example test case in BGP-4 protocol conformance testing. After this class, we also spent one hour to show how to download, install and use the TWorkbench tool. Besides, the course also addressed model-based testing, FSM-based testing, LTS-based testing, and test engineering for about 5 classes.

For the course project, students were divided into 4 groups of 3 to 4 students. Each group selected one course related topic to conduct their project. Out of 4 groups, 2 groups selected topics related to protocol testing and TTCN-3.

One group used both TWorkbench and the model-based testing tool Conformiq Designer to perform conformance testing of an FTP protocol. At first, they designed a model and generated TTCN-3 test cases automatically with the Conformiq Designer. Afterwards they executed and analyzed these test cases with TWorkbench. Within their work, the students implemented a small part of a simple model for FTP protocol to generate related TTCN-3 test cases. They also implemented a test adapter for testing FTP protocol and finally performed practical testing. Thus, they performed a complete process of so called "model-based testing".

Another group tended to study the conformance testing of RPL (IPv6 Routing Protocol for Low-Power and Lossy Networks) protocol. They used TWorkbench to write some test cases, but did not perform testing eventually.

## Our Plans for the Future

We hope to continuously participate in the educational program of Testing Technologies. For the autumn semester of 2012/2013 we are planning to design a course project to test some new network protocols, e.g. OpenFlow. From the perspective of research we want to find out whether current formal methods and tools can be used in testing future Internet protocols.

## Instructors of the Course

Mrs. Xia Yin, Professor

Mrs. Yin has received the B.E., M.E. and Ph.D. degrees in computer science from Tsinghua University, China in 1995, 1997 and 2000 respectively. Currently she is a Professor in the Department of Computer Science and Technology of Tsinghua University. Her research interests include next generation Internet, formal methods and protocol testing, as well as network measurement.

Mr. Zhiliang Wang, Associate Professor

Mr. Wang has received the B.E., M.E. and Ph.D. degrees in computer science from Tsinghua University, China in 2001, 2003 and 2006 respectively. Currently he is an Associate Professor in the Institute for Network Sciences and Cyberspace at Tsinghua University. His research interests include formal methods and protocol testing, next generation Internet, and network measurement.



„Seeing these students experiment and work with the test automation platform TWorkbench, we recognize how helpful "real-life" tools are for them to practice protocol testing and TTCN-3. They give them such a better understanding of taught concepts and technologies. We highly appreciate the cooperation with Testing Technologies and the opportunity for our students to work with their user-friendly TWorkbench.“