ITEA 2
INFORMATION TECHNOLOGY FOR EUROPEAN ADVANCEMENT

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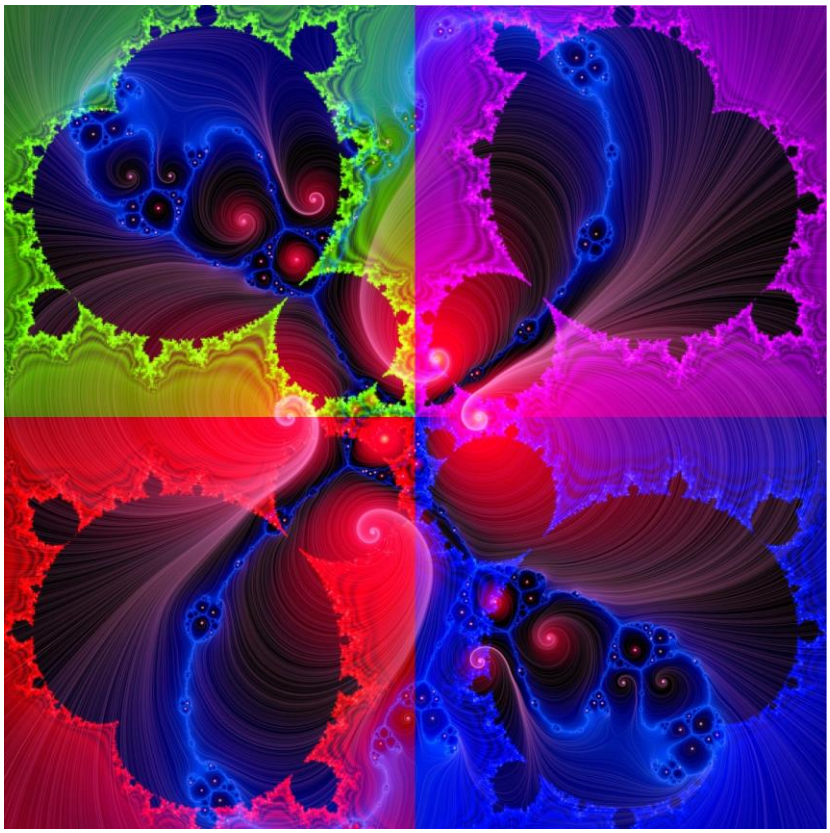
ATAC project final report for Tampere University of Technology sub project



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1. Introduction

This is the final report from Tampere University of Technology (TUT) for the project Advanced Test Automation for Complex Software-Intensive Systems (ATAC), funded by Tekes (project officer Olavi Keränen) and TUT.

The research topic in the project was test automation used in testing of complex, software-intensive systems, for example automation systems, complex information systems or multi-platform mobile systems.

The project was executed as a collaboration project where other parties had their individual projects, both in European level ITEA2 ATAC project and in its Finnish consortium. The other parties in the Finnish ATAC consortium were Adensy, Elektrobit, F-Secure, Metso Automation, Tekla and VTT. The project was executed between 1.5.2012 and 31.12.2014.

The ITEA2 ATAC project has a web site at http://atac.testautomation.fi/.

TUT has a separate web page where our public reports are available at http://www.cs.tut.fi/~ratac/atac/.

This report looks into the collaboration project from the perspective of TUT, department of pervasive computing, which had a role of research institution in the project, based on our experience of test automation systems and especially model-based testing.

2. Project execution

2.1 Execution and content

The research topic in the project was test automation used in testing of complex, software-intensive systems, for example automation systems, complex information systems or multi-platform mobile systems.

The project was executed as a collaboration project where other parties had their individual projects, both in European level ITEA2 ATAC project and in its Finnish consortium.

The basic idea in ATAC was to develop test automation systems and testing practices integrated in product development, in use cases provided by companies. In those, new testing technologies and tools would be developed, tools would be integrated into tool chains and workflows and the results would be introduced to the European industry. Research institutes and testing tool providers would work in this with companies in close collaboration.

That is also mirrored in TUT's role, which was two-fold:

- TUT worked in collaboration with Finnish companies, giving consultation in tool usage, tool training, tailoring of tools for the companies to try out. During that confidential work, many issues were abstracted and published as reports to the ATAC consortium and, at the end of the project period, more widely to the industry.

- TUT had a special interest to develop TEMA (http://tema.cs.tut.fi/), an open source bases model-based testing toolset, which used technology that been long in the development, but still needed development to be suitable for industrial use and for today's ways of agile development.

But as ATAC was an industry-driven project, TUT did not restrict itself to developing and promoting TEMA. In ATAC's sibling project RATA (https://wiki.tut.fi/RATA), TUT's researchers had used fMBT by Intel (http://01.org/fmbt/), also an open source model-based testing tool, and found it suitable for many practical testing tasks. Because of that, it was used as a platform for presenting new testing techniques and was piloted by one company.

The practical tasks in the project were the following:

- Participation in the synthesis of state of the art of advanced test automation along with experts from other ATAC parties (especially research institutes).
- Collaboration and support for case study companies that provided "use cases" for testing technology development.
    - Tool development to support the case studies; making tool proposals and demos.
    - Giving focused training on model-based testing and the tools used.
- Supporting research on design principles of next generation testing tools and the utilisation of testing in modern product development.
- Collecting dissemination material information during the project from ATAC parties.
- Collaborating in European level ATAC consortium activities as needed.

2.2 Resources and collaboration

TUT's personnel in the project included:

- Management: Professor Hannu-Matti Järvinen.
- Project manager: Hannu-Matti Järvinen.
- Researchers: Antti Jääskeläinen, Heikki Virtanen and Matti Vuori.
- Original project planning: Mika Katara (currently working at Intel).

Our work in ATAC was divided into two levels: 1) National level work in the context of our project plan and with Finnish companies and 2) EU level work in the context of the whole European ATAC collaboration network.

Finnish consortium

The Finnish ATAC consortium had a shared steering group with VTT's sub project. It had members from the Finnish companies that had their own projects in ATAC and Tekes representative. Members of the steering group were Toni Halsti (Adensy), Jarkko Kaippio (Elektrobit), Jari Still (F-Secure), Antti Välimäki and later Mika Karaila (Metso Automation), Hannu-Matti Järvinen (TUT), Marjut Hämeenaho (Tekla), Hannu Honka (VTT) and Olavi Keränen (Tekes).

The project also had a named expert group consisting of Mika Karaila (Metso Automation), Jani Metsä (Elektrobit), Teemu Kanstren (VTT) and Tomi Räty (VTT).

In practice, the Finnish consortium worked in an informal manner, inviting all representatives from the parties to official steering group meetings. Steering group had meetings every three months and between those, unofficial meetings were held, often as teleconferences.

The main collaboration parties were obviously the other parties of the project. TUT worked in collaboration with two companies (Metso Automation and Tekla) supporting their case studies.

European collaboration in ITEA2 ATAC

The project and all projects in the Finnish consortium had an umbrella in European level with ITEA2 project ATAC (http://atac.testautomation.fi/). Its members were the Finnish consortium members and Barco N.V. (Belgium), Bombardier Transportation (Sweden), Maximatecc (Sweden), Ericsson (Sweden), Kaunas University of Technology (Lithuania), Mälardalen University (Sweden), SICS (Sweden) and Singleton Labs (Lithuania).

TUT project mirrored a subset at that project. We also had specific responsibilities in the European level in its work packages, most notably coordination of the dissemination work package.

The European level consortium had plenary meeting usually every three months in all participating countries. Antti Jääskeläinen was most often our representative in those. Each country had a country coordinator, in Finland Pekka Aho from VTT. TUT also participated in ITEA2 project reviews for ATAC.

Other collaboration

During the period, TUT had another research project Robot Assisted Test Automation (RATA), https://wiki.tut.fi/RATA, which targeted testing of complex software systems. ATAC and RATA had a lot of synergy. VTT also participated in that project.

Synergy in education

Action-based computing is an essential new technology in the development of many kinds of testing systems (especially model-based testing systems) and future automation systems, but not much present in engineering education. In 2014 TUT had a seminar course Action Based Computing (led by Hannu-Matti Järvinen) to spread and create knowledge of that area.

2.3 Possible problems and changes to original plans

ATAC as whole was for a long time in the development and in addition to that, funding decisions in Finland were delayed. That affected the original plans for collaboration in companies' case studies – the original issues to be solved were no longer acute and key persons in companies had in some cases changed. Because of that, the industry collaboration was refocused to companies that would benefit from TUT's input.

The economy of some companies hindered tool trials, as they had to release the people who were allocated to for example tailoring TEMA to the company's needs. That reduced the potential impact of TEMA and also reduced the need to develop it further in its present form. Instead, a decision was made to refocus TEMA into a more packaged test generation tool that could be integrated into workflows consisting of other tools for test design and execution. That work is still underway.

3. Summary of project results

3.1 General

The EU level ATAC innovation report was published in ITEA Magazine November 2014: https://itea3.org/publication/download/itea-magazine-october-2014-19.pdf (page 20) and is separately available at https://itea3.org/innovation-report/high-quality-fast-automated-testing.html

3.2 Development of TEMA toolset

Tool description

TEMA is an open source model-based testing toolset which includes various tools for different model-based testing activities. The toolset is available at http://tema.cs.tut.fi/

Model Designer is a tool for creating and managing a library of model components. Each component models one aspect of some system to be tested, and the metadata in the library keeps track of which components can be used to test which kinds of systems. Test management tools can be used to select a number of components from the library and assemble them into a test model suitable for testing the current system under test, as well as deciding what kind of test should be generated. Once the test model is ready, test generation tools can begin generating a test from it according to the instructions. TEMA is designed to perform online testing, so the test steps produced by the test generation tools are executed immediately and the results fed back into the generation process, which enables the testing of nondeterministic systems. The toolset includes some execution tools mostly for testing smartphones, and the tool interfaces allow the development of others. In addition, there are a number of smaller tools that help in analysing the models and debugging the long error traces commonly produced by model-based testing.

Tool improvement in the project

The model creation and test generation tools have been improved to support parametrized models. A parametrized model component acts as a template from which several versions can be instantiated into the test model. This greatly eases the testing of systems with a variable architecture, as the currently desired structure can be defined in a simple parameter file without modifying the model components themselves.

Furthermore, a new version of TEMA is currently being developed to better leverage the strengths of the toolset: a flexible management of the model library for testing product families and the ability generate many different kinds of tests according to current testing needs. Model creation tools are de-emphasized in favour of importing and combining models created with other model-based testing tools. This new version of the toolset has not yet been released. The lead developer of TEMA is currently Antti Jääskeläinen.

Tool application in the case studies

Parametrized models were developed and used in one case study. Parametrized models are important in cases where a system consists of many alternative components for a task and the specifications of configurations vary. With parametrisation, the models can be easily – preferably automatically, based on a component library – configured to meet any particular current system configuration or architecture. Experimental level parametrisation support was added to TEMA's current version.

Besides that, studies were made in cases where a manually executed linear test sequence was expressed as a test model, making it possible to test simple subsystems thoroughly. That study was proof of a concept type, mostly done to try the testing approach in that context and was left lacking the necessary toolchain infrastructure.

TEMA was also used as an educational tool to explain and demonstrate the model-based approach to one company.

Related publications and presentations

Antti Jääskeläinen, Tommi Takala, and Mika Katara, 2012. Model-based GUI testing of Android applications. In: Experiences of Test Automation: Case Studies of Software Test Automation, Dorothy Graham and Mark Fewster, Eds. Upper Saddle River, NJ, USA: Addison-Wesley (Pearson Education), Jan. 2012, ch. 14, pp. 253–275.

3.3 Report on state of the art in advanced test automation of complex software-intensive systems

TUT participated in synthetizing the state of the art in advanced test automation of complex software-intensive systems. This was first done in the beginning of ATAC to support ATAC's activities and later updated with new information gained in the development and research. The results are available in the report:

- Pekka Aho (VTT), Teemu Kanstrén (VTT), Kivanc Doganay (MDU), Eduard Paul Enoiu (MDU), Antti Jääskeläinen (TUT), Sarunas Packevicius (KTU), Robertas Jasaitis (KTU), Mantas Mite (KTU), Eduardas Bareisa (KTU), Dominykas Barisas (KTU), Virginija Limanauskiene (KTU) & Sigrid Eldh (Ericsson). 2014. Processes and Methods for Advanced Test Automation of Complex Software-Intensive Systems. ATAC State-of-the-art document. 50 p. Available at: http://www.atac.testautomation.fi/uploads/ATAC_T2.1_State-of-the-Art-document_2014-05-28.pdf

3.4 Other reports on test automation

3.4.1 Test automation in general

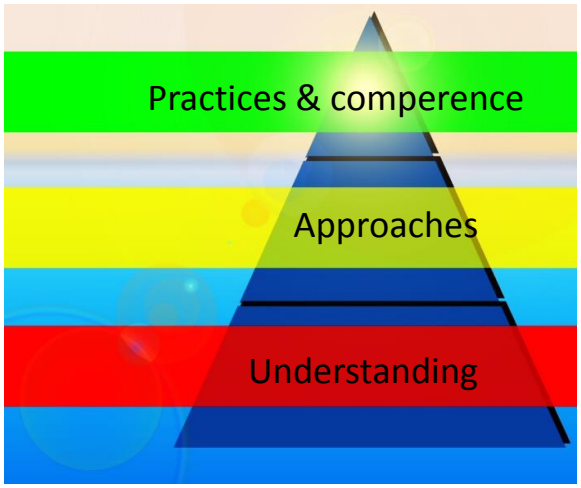

Figure 1. Steps to excellence in testing

Test automation is beginning to be used much more widely in every domain. That is why it is critical to understand its role in the overall testing activity. Deep understanding of the issues is particularly important, as the industries are moving towards more rapid and agile way of product and systems development.

To support that, TUT wrote reports and articles that discuss the issues:

- Matti Vuori. 2014. Support from testing for fast and dynamic software development. ATAC report. 21 pages. Available at: http://www.cs.tut.fi/~ratac/atac/ATAC_report_testing_in_fast_product_development.pdf
- Matti Vuori. 2014. Model-based testing in modern agile software development - How to integrate it into the development process?. ATAC report. Tampere University of Technology. 14 p. Available at: http://www.cs.tut.fi/~ratac/atac/ATAC_report_MBT_in_modern_agile_development.pdf
- Matti Vuori. 2013. Noin 80 ajatusta testiautomaatiosta TestausOSY - FAST website. Tampere University of Technology. 5 p. Available at: http://testausosy.fi/wp-content/uploads/2013/06/noin_80_ajatusta_testiautomaatiosta.pdf
- Matti Vuori. 2014. Around 80 thoughts about test automation. TestausOSY - FAST website. Tampere University of Technology. 5 p. http://testausosy.fi/wp-content/uploads/2014/01/around_80_thoughts_about_test_automation.pdf
- Matti Vuori. 2014. 90 ajatusta testitapauksista. Laatu & Testaus 1/2014. s. 4-10. Available at: http://testausosy.fi/wp-content/uploads/2014/12/LT-Vol3Ed1.pdf.

3.4.2 Reports on testing tool design

The culture of testing tools has evolved to a stage where they fulfil the technical purpose they are planned for. The next steps will be in developing really productive tools that support more fully the mind set and the tactics of good testing. There is a need to consider more the usability of the tools and user (tester) experience of using the tools. That is a consideration for both tool developers and to companies that choose tools for their use.

To support tool development – at TUT and elsewhere – and selection TUT wrote reports on the topic:

- Matti Vuori. 2014. User-centered model-based testing tool design - Design principles for testing tools that provide best possible tester experience . ATAC report. Tampere University of Technology. 16 p. Available at: http://www.cs.tut.fi/~ratac/atac/ATAC_report_user_centered_MBT_tool_design.pdf
- Matti Vuori. 2014. About selecting open source model-based testing tools. ATAC report. Tampere University of Technology. 13 p. Available at: http://www.cs.tut.fi/~ratac/atac/ATAC_report_OSS_MBT_tool_selection.pdf
- Matti Vuori. 2014. Testiautomaation ohjelmistojen piirteistä ja valinnasta. Testiautomaatio 2014, Tampere University of Technology. 13 slides. Available at: http://www.cs.tut.fi/tapahtumat/testiautomaatio14/kalvot/Vuori_testiautomaation_ohjelmistojen_piirteista_ja_valinnasta.pdf

3.4.3 Special reports on issues in testing

During ATAC we noted some special issues in testing that required attention and documentation that would aid companies. Those include strategies related to testability and practical modelling issues.

- Matti Vuori. 2014. Dealing with testability issues - some patterns for solutions . ATAC report. Tampere University of Technology. 7 p. Available at: http://www.cs.tut.fi/~ratac/atac/ATAC_report_testability_problems_and_solutions.pdf
- Antti Jääskeläinen & Heikki Virtanen. 2013. Modeling: How to get started with real apps. Test modelling workshop for local companies that participate in related project RATA. Finland. 11 March 2013. Available at: https://wiki.tut.fi/pub/RATA/PublicationsAndDownloads/real_apps.pdf
- Vuori, Matti & Jääskeläinen, Antti. 2013. Quality of MBT Test Models and Competences Needed for Creation of Good Models - Or How Does ISO/IEC 25010 Help Us Understand What Good Test Models Are Like. 6 p. (Unpublished manuscript)
- Henri Heiskanen, Antti Jääskeläinen, Heikki Virtanen, Mika Katara & Antti Kervinen. 2013. Methods for Debugging and Error Trace Shortening in System Level Black-Box Testing. (Unpublished manuscript)

3.4.4 Meeting future challenges in changing technology

The world of technology is changing. Today the systems we use and test are quite traditional “devices”, “applications”, “information systems” or “automation systems”, but the next phase will be in some cases something else. And when we do strategic research and development, we need to take looks into the future so we can plan the tool and method development a little ahead.

One very interesting technology area is the utilisation human-like robots. In ATAC’s sibling project RATA, TUT got familiar with robots used as testing tools and at the same time the media was full of stories about human-like robots. Thus it seemed feasible to shortly assess testing of those. That resulted as the report:

- Matti Vuori. 2014. Testing of human-like robots. RATA & ATAC project report. Tampere University of Technology. 8 p. Available at: https://wiki.tut.fi/pub/RATA/PublicationsAndDownloads/testing_human-like_robots.pdf

3.5 Indirect results in companies’ case studies

As ATAC was an industry-led project based on development in companies, one area of the research institutes’ results is influence on the improvements in the company. This includes:

- Improved knowledge about testing and possibilities of testing tools.
- Understanding of model-based testing.
- Improved understanding the current state their test systems and current tools, leading to focused tool development and selection.

Still, TUT’s role was not integral in the case studies, but supportive. Furthermore, the case studies were confidential and we cannot disclose any details.

The collaboration was, however, very useful for TUT as it made it possible for the researchers to become familiar with new domains, new problems in testing and test automation. That will be a benefit in coming years.

4. Utilisation of the results

4.1 Dissemination of the competences and new information during the project

ATAC was and industry-driven collaborative project. Results were disseminated within the ATAC consortium – containing the European and Finnish companies – as working reports during the project.

Dissemination to Finnish industry was mostly done during the last year of the project, when two dissemination seminars were arranged. First in June in Tampere, the Testiautomaatiopäivä 2014 seminar (http://www.cs.tut.fi/tapahtumat/testiautomaatio14/) in collaboration with RATA project (around 200 participants) and in November in Oulu, the seminar Testiautomaatio tänään: Käyttötapauksia ja tutkimusta (http://testausosy.fi/event/testausosy-oulu-ilmainen-seminaari-testiautomaatio-2014-kayttotapauksia-ja-tutkimusta/), in collaboration with TestausOSY (around 60 participants).

4.2 Views into utilisation of the results

The Finnish industry in general can utilise the results in the development of testing practices and workflows and in developing and selecting tools for automated testing.

The information about tool design will aid developers of testing tools, which is already a strong element in Finnish testing.

TUT will utilise the results in the development of existing testing tools, such as TEMA and in the development of other tools for any particular needs in industry or research.

The results also generated insight which is valuable in testing education at TUT.

4.3 Indirect effects of the project on other organisations and the society

Finland of today and future lives on advanced technology and its high quality and managed risk level are an absolute necessity. Reaching high quality in rapid product and systems development requires high-level understanding of testing and testing tools that are excellent in their use. Research on testing supports that directly by helping companies advance in their actions and indirectly by building the competences of whole community. Those are also the benefits of ATAC.