EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

Exploratory Workshop Scheme

Standing Committee for Physical and Engineering Sciences (PESC)

ESF Strategic Workshop on

Correct Software in Web Applications

Hagenberg (Austria), 26-28 September 2011

Convened by:

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SCIENTIFIC REPORT

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Co-sponsored by International Collocation Centre Hagenberg

1. Executive summary

The workshop on "Correct Software in Web Applications" was held at the Research Institute for Symbolic Computation (RISC), part of the Johannes-Kepler-University Linz, in Hagenberg, Austria over three days. Originally, 30 participants from 12 countries have been invited, but despite the interest in the topics several planned participants could not attend. At the end 26 participants from 7 countries participated at the workshop.

The scientific rationale of the workshop was to bring together different research communities in web applications engineering and formal software engineering methods with the expectation that this will result in a clearer picture of the research challenges in combining these two areas. Identifying the imminent research questions that have to be addressed in order to achieve correctness in web applications is the first step toward the realization of the dream of computation in the public domain across the internet, in which large portions of software can be integrated by means of services that are made publicly available. It was envisioned by the workshop convenors that this will ultimately lead to solid, mathematically grounded software development methods for web applications together with provably correct verification techniques. More detailed, the objectives of the workshop were the following:

1. Obtain a common understanding of the challenging research questions in web applications comprising web information systems, web services, and web interoperability.
2. Obtain a common understanding of verification needs in web applications.
3. Achieve a common understanding of the available rigorous approaches to system development, and the cases, in which they succeeded.
4. Identify how rigorous software engineering methods can be exploited to develop correct web applications.
5. Develop a European scale research agenda comprising theory, methods and tools that would lead to correct web applications with the potential to realize systems for computation in the public domain.

The workshop programme consisted of presentations and intensive discussion rounds. The presentations covered Abstract State Machines and Event-B as formal methods and experiences in applying them to selected fields of web applications, Theorema and KIV as verification methods and experiences made with these tools for web applications, and various detailed descriptions of facets of the large field of web applications such as web information systems with emphasis on story boarding and media types, recommender systems, common protocols such as HTTP, browser technology, scripting technology, security aspects of web services, and web services orchestration. The three discussion sessions addressed the characterisation of what constitutes a web application, what does correctness mean in this context, and what is a common umbrella for a research agenda in this field.

The workshop organisation enforced a lively discussion atmosphere, which even continued during the breaks and in the evenings, as all external participants stayed in the same hotel and each evening the participants came together over dinner. The time schedule was handled very liberally, so in most cases the discussion took much more room than originally planned.

All together, the ambitious objectives of the workshop could not yet be fully achieved. This would have required much more intensive discussions and the exchange of draft summary papers. However, with respect to obtaining a common understanding of challenging research questions, verification needs, and rigorous methods to approach the problems (objectives 1-4) every participant learned about this, so a step into this direction was done. On these grounds the discussion rounds led to an initial idea of a research agenda (objective 5), which still needs plenty of time to be consolidated.

This in mind the workshop participants agreed to continue the collaboration. It is planned to apply for a network of excellence (NoE) "Correct Software in Web Applications" (CorWA) under ICT Call 8 in the 7th EU Frame Programme. The NoE CorWA shall ultimately lead to a common research agenda to which all partners will contribute.

In parallel, the convenors of the workshop will edit a book in the RISC series of Springer-Verlag summarising the proceedings of the workshop and elaborating a joint research perspective. The book shall be published in 2012.

Furthermore, the participants agreed that web applications constitute a perfect example of collective adaptive systems, i.e. systems that are subject to threats arising from changes in the environment such as non-availability or changes to components as well as security and privacy threats arising from unknown behaviour of others. It is therefore planned to develop a joint proposal for a European project under FET Proactive FOCAS in ICT Call 9 of the 7th EU Frame Programme.

Unfortunately, there is no open call for an application to EUROCORES and for an ESF Research Networking Programme. Therefore, all follow-on activities are directed towards open opportunities in the 7th EU Frame Programme.

2. Scientific content of the event

The scientific programme was organised in a way that presentations from the application field were followed by presentations on formal specification and verification means. Each day ended in an open discussion trying to bring together the different directions that were presented. The final discussion on the last day concentrated on follow-on activities.

In his presentation on Web Information Systems Bernhard Thalheim focused on the co-design approach to the design and development of web information systems and the experiences made in this field since the start around 15 years ago. He elaborated the different problem areas that have to be addressed such as content to be presented, presentation, functionality, story, i.e. the usage of the systems, user intentions and context, and briefly reported on various web engineering methods with a limited view on only the data and content management aspects. He briefly sketched technical fundamentals such as storyboarding, life cases, media types, deontic dependencies, etc. With respect to correctness he emphasised partial formalisation done with Abstract State Machines (ASMs), but concluded that it is still open what should be meant by correctness with respect to web information systems.

The discussion during and after the presentations addressed partly technical understanding of concepts, but also picked up the question of what would correctness mean. A first attempt was made to distinguish the level of user satisfaction, i.e. fulfillment of requirements and trustworthiness, and formal consistency of the system.

Vincenzo Gervasi highlighted a completely different aspect of web applications targeting programming frameworks as defined by browser technology, basic interaction protocols such as HTTP and SMTP, and client-side scripting by means of languages such as Javascript. He emphasised the lack of principles and missing theory and the presence of lots of tools. The desirable properties investigated in a project in Pisa were responsiveness, security, reliability and synchronisation. In particular, he described the activities towards ASM-based modelling the browser including a model of HTTP, streaming, DOM processing of HTML, rendering and event handling, and modelling of Javascript interpreters.

The discussion during and after the presentation concentrated on understanding the difficulty of the problem, which already arises from the lack of agreement of what actually should be

supported in the applications. Furthermore, the discussion on what is meant by correctness in this area continued.

The presentations by Bruno Buchberger and Tudor Jebelean were dedicated to the theorem proving approach of the Theorema project. Bruno Buchberger started from the S-polynomials in his seminal work on his algorithmus to construct Gröbner bases. He concentrated on the problem to construct algorithms out of proofs by exploiting schemes, and exemplified this on two examples using the divide and conquer scheme and the critical pair completion scheme. For the latter one he could show that his own algorithm results when the scheme is applied to the problem of finding Gröbner bases. Tudor Jebelean took this further explaining that this approach to algorithm construction forms the core of the Theorema idea. On these grounds he described the ideas of the project with respect to software verification.

The follow-on discussion tried to link the Theorema approach to verification with the problems identified before in web applications. It was concluded that the approach might be worth investigating for verification of consistency of web information systems. It was also pointed out that heorema might be linked to the use of new objects from the reserve in the theory of ASMs.

Temur Kutsia presented his recent work on symbolic computation to solve unification problems with unranked terms, in particular hedges. Hedges appear naturally in XML, and several hedge algebras have been introduced so far. Unification would link these to declarative, symbolic computation in the context of web applications.

The discussion concentrated on the question how the work could be linked to the overall theme of the workshop and again on correctness.

The first open discussion round was moderated by Gerhard Schellhorn and Andreas Prinz. Non-surprisingly, the emphasis was on the problem of characterising correctness in web applications. It was pointed out that part of the problem is a lack of foundations and a huge amount of tools, so a suitable solution might be to concentrate on the specification of web applications as particular distributed systems and proofs of consistency. The particularities include the dependence on browser technology and scripting without common semantics. However, it was argued that this view would be still too narrow, so also an anticipation of what might cause problems would be due. In particular the openness of the web may cause interference with other web applications, which should be taken into consideration. It was further pointed out that correctness of web applications highly depends on the anticipation of user behaviour, which therefore consitutes another aspect of the theme.

The presentation by Meike Klettke was dedicated to explain recommender systems as a particular class of web applications. She emphasised that in these systems similarity measures play an important role, and user feedback is used to tune them. The discussion centered around the question, whether similarity is suitable as a basis for recommendations, and how domain-specific guidelines for recommendations could be exploited.

Elena Ferrari's presentation addressed security and privacy issues in web service compositions. First she described the state-of-the-art in web service composition based on WSDL for service description, UDDI for publishing, OWL-S for semantically enriched description, SOAP for message exchange on top of HTTP/SMTP and BPEL for specification of orchestration, i.e. the processes combining services. She highlighted the key problem to ensure that the security requirements are respected. Key technologies in place are encryption techniques and the use of trusted third parties.

In the discussion the suitability of the existing technology and approaches was questioned, in particular with security requirements stored in WSDL documents or SOAP messages. It was also questioned, whether trusted third parties should not be considered as part of the problem. Also the expressiveness of the used techniques, in particular BPEL was discussed.

In his presentation on Abstract State Machines Egon Börger concentrated on the communication aspect that arises in any parallel or distributed computation. While in the ASM thesis this is solved only implicitly by means of the global state, he outlined an explicit specification of synchronous as well as asynchronous communication as in the ASM specification for S-BPM. He explained how this specification supports a virtual provider model.

The discussion identified explicit specification of communication as a central aspect in web applications. This led to a continued discussion of what would actually be expected from web services interaction beyond state-of-the-art. In particular, communication between web services, interaction, and the ability to eliminate redundant components were mentioned as areas for improvements.

Alexander Raschke reported on the latest version of UML activity diagrams, and presented how "active classes" could be specified using ASMs. He further explained how ASML and the SpecExplorer tool were used to validate the specification. The discussion centered around the similarities and differences between activity diagrams and other techniques for orchestration of web services compositions. It was highlighted that despite some differences (and many similarities) the key problems identified before are not solved in any of the approaches.

Gerhard Schellhorn dedicated his presentation to the verification of ASM specifications. Using examples such as the UBIFS flle system and the Mondex electronic purse he emphasised verification with the KIV theorem prover, which he then described in some detail. In the discussion the central question was how verification of security and privacy in web applications could benefit from the verification approach. It was concluded that attacks have to be added to the specification in order to prove results about the combination.

The second open discussion round made an attempt to characterise more clearly the specific properties of web applications in order to find out which specific research questions have o be addressed. The discussion round was moderated by Anne Brüggemann-Klein and Vincenzo Gervasi. On one hand there are web applications running in browsers that have components in servers on the web, on the other hand there are compositions of web services. It was felt that process or workflow specifications definitely play an important role in the field. One decisive feature is the vulnerability with respect to privacy and security aspects. Another one is the spectrum of involved actors such as users, developers, attackers, and providers. In order to support the refinement-based transition from requirements over specifications to implementations ASM specifications might be useful, while there is a large playground for verification. The discussion round did not yet come to a final conclusion how to tailor the immense width of the area to a manageable research field.

Yamine Ait-Ameur's presentation on the last day addressed the formal specification and verification of web service compositions. In his case the web service compositions were assumed to be given in BPEL and Event-B was the formal method applied. The key problem was adaptability, i.e. the behaviour under replacement of services. The discussion concentrated on the technical aspects of the presentation, in particular the encoding of process algebras in Event-B.

The presentations by Elvinia Riccobene, Patrizia Scandurra and Paolo Arcaini addressed ASM specifications for service-oriented applications with particular emphasis on using the ASMeta framework. In this case the composed workflow was based on the service component architecture SCA. In particular, Elvinia Riccobene emphasised the specification of SCA in ASMs, Patrizia Scandurra stressed server coordination as a particular example, and Paolo Arcaini described the validation and verification using ASMeta.

Besides discussion technical details and differences between SCA and other web workflow languages and specific experiences made with ASMeta it was attempted to further develop an understanding of web applications.

Elvinia Riccobene and Klaus-Dieter Schewe moderated the third open discussion round, which made another serious attempt at characterising web applications. First, the different kinds of applications such as web information systems, browser-based systems, web service compositions, etc. are to be brought under a common umbrella. It was suggested to consider a wider notion of service, which would enable to subsume all these applications under the umbrella of a large-scale, distributed service. Same as current web services the publication, search and selection, orchestration/instantiation, messaging activities would characterise activities around building such applications. For correctness aspects the focus should be on the processing of the orchestration and the messaging involved. Furthermore, specific features arising from the openness were identified. In particular, components are subject to change and varying availability, security and privacy threats arise from common use of the same servers and communication channels, and end-users ultimately define trustworthiness by means of expectations, constraints, transparency, security and privacy. Addressing correctness would thus mean to aim at formal specifications that explicitly take the openness and the environment into account, derive particular proof obligations, and thus enhance requirements elicitation, specification, verification, refinement and implementation in a systematic way. At the end of the discussion it was agreed that this could be a viable definition of web application and correctness, which could serve as a basis for further collaboration.

The final discussion concentrated on concrete next steps. It was decided to aim for a proceedings volume either in LNCS or in the RISC series, to apply for a Network of Excellence under the Objective Trustworthy ICT in FP7, and to apply for a FET Proactive project in Call 9 of FP7.

3. Assessment of the results, contribution to the future direction of the field, outcome

As already indicated above, the ambitious objectives could not yet be fully achieved, but a first rough understanding of the challenges in assuring correctness of web application software was reached. The field is far too big and too diverse to expect that within a few days a common research agenda could be worked out in detail. As a side result all participants learned that the field is even wider than already expected.

Nonetheless, the convenors are very happy with the way the workshop was running (very intensive and constructive discussions) and with the results. The achieved understanding of the problems in web applications and the potential of formal specification of verification techniques for solving them are sufficient for starting a fruitful collaboration among the workshop participants.

Furthermore, the convenors are very happy that the participants agreed on several concrete actions:

1. It is intended to publish a proceedings volume in the RISC series of Springer-Verlag. The editor of the series and the publisher have gratefully accepted the publication proposal. The book shall not merely contain the work presented during the workshop, but also elaborate the challenges in web applications as identified in the discussion rounds.
2. It is intended to continue the collaboration among the participants (plus some others, who were originally invited, but could not attend due to conflicting obligations) in the form

of a network of excellence. A corresponding application in ICT Call 8 under EU FP7 is currently under development.

3. It is intended to further apply for a collaborative project in ICT Call 9 under EU FP7. The project shall be placed within the FET Proactive scheme addressing fundamentals of collective adaptive systems (FOCAS).

4. Final programme

Sunday, September 25, 2011

Afternoon	*Arrival*

Monday, September 26, 2011

08.30-08.50	**Welcome by Host and Convenors incl. Presentation of the European Science Foundation (ESF)** **Bruno Buchberger** (RISC, Hagenberg, Austria) **Klaus-Dieter Schewe** (SCCH, Hagenberg, Austria)
08.50-10.40	**Session I: Web Information Systems**
08.50-10.20	**Presentation 1 "Foundations and Modelling of Web Information Systems"** **Bernhard Thalheim** (Christian-Albrechts-University Kiel, Kiel, Germany)
10.20-11.20	**Presentation 2 "Abstract State Machine Specification for Web Applications"** **Vincenzo Gervasi** (University of Pisa, Pisa, Italy)
11.20-11.50	*Coffee / Tea Break*
11.50-13.20	**Session IIa: Theorema**
11.50-12.20	**Presentation 3 "Introduction to the Theorema Project"** **Bruno Buchberger** (RISC, Hagenberg, Austria)
12.20-13.20	**Presentation 4 "A Logical Approach to Total Correctness"** **Tudor Jebelean** (RISC, Hagenberg, Austria)
13.20-14.10	*Lunch*
14.10-15.00	**Session IIb: Theorema (cont.)**
14.10-15.00	**Presentation 5 "Symbolic Computation Techniques for XML"** **Temur Kutsia** (RISC, Hagenberg, Austria)
15.00-16.10	**Session III: Discussion**
15.00-16.30	**Moderated Discussion 1: Verification & Web Information Systems** **Andreas Prinz** (University of Agder, Grimstad, Norway) **Gerhard Schellhorn** (University of Augsburg, Augsburg, Germany)
16.30-17.00	*Coffee / tea break*
17.00-17.30	**Session IV: Summary**
17.00-17.30	**Summary of Discussion 1: Verification & Web Information Systems** **Andreas Prinz** (University of Agder, Grimstad, Norway) **Gerhard Schellhorn** (University of Augsburg, Augsburg, Germany)
19.00	*Dinner*

Tuesday, September 27, 2011

08.30-10.50	**Session V: Web Services**
08.30-09.20	**Presentation 6 "Using Recommender Technology for Designing Applications"** **Meike Klettke** (University of Rostock, Rostock, Germany)
09.20-10.50	**Presentation 7 "Security and Privacy Issues in Web Service Composition"** **Elena Ferrari** (University of Insubria, Insubria, Italy)
10.50-11.20	*Coffee / Tea Break*
11.20-13.00	**Session VIa: Abstract State Machines**

11.20-12.30	**Presentation 8 "Using ASMs for Modelling and Analysis of Web Services"** **Egon Börger** (University of Pisa, Pisa, Italy)
12.30-13.30	**Presentation 9 "Experiences with ASMs by Defining UML Semantics and Possible Applications in Modelling Web Services"** **Alexander Raschke** (University of Ulm, Ulm, Germany)
13.30-14.20	*Lunch*
14.20-15.30	**Session VIb: Abstract State Machines (cont.)**
14.20-15.30	**Presentation 10 "MDD, ASMs, Refinement: Some Ideas for a Development and Verification Approach for Web Applications"** **Gerhard Schellhorn** (University of Augsburg, Augsburg, Germany)
15.30-16.40	**Session VII: Discussion**
15.30-16.40	**Moderated Discussion 2: ASMs, Verification & Web Applications** **Anne Brüggemann-Klein** (Technical University of Munich, Munich, Germany) **Vincenzo Gervasi** (University of Pisa, Pisa, Italy)
16.40-17.10	*Coffee / tea break*
17.10-17.40	**Session VIII: Summary**
17.10-17.40	**Summary of Discussion 2: ASMs, Verification & Web Applications** **Anne Brüggemann-Klein** (Technical University of Munich, Munich, Germany) **Vincenzo Gervasi** (University of Pisa, Pisa, Italy)
19.30	*Dinner*

Wednesday, September 28, 2011

08.30-10.30	**Session IXa: Web Interoperability**
08.30-09.40	**Presentation 11 "Formal Modelling of BPEL Web Services Compositions within the Event-B Method"** **Yamine Ait-Ameur** (Ecole Normale Superieure de Mecanique et d'Aerotechnique, Poitiers, France)
09.40-10.50	**Presentation 12 "An ASM-Based Modelling and Execution Language for Service-Oriented Applications"** **Elvinia Riccobene** (Polytechnico di Milano, Milan, Italy)
10.50-11.20	*Coffee / Tea Break*
11.20-12.20	**Session IXb: Web Interoperability (cont.)**
11.20-11.50	**Presentation 13 "An ASM-Based Framework for Coordinated Simulation of Heterogeneous Service-Oriented Applications"** **Patrizia Scandurra** (University of Bologna, Bologna, Italy)
11.50-12.20	**Presentation 14 "Analysis and Run-Time Monitoring of Software Components by ASMs"** **Paolo Arcaini** (University of Bologna, Bologna, Italy)
12.20-13.30	**Session X: Discussion**
12.20-13.30	**Moderated Discussion 3: ASMs, Verification & Web Interoperability** **Klaus-Dieter Schewe** (SCCH, Hagenberg, Austria) **Elvinia Riccobene** (Polytechnico di Milano, Milan, Italy)
13.30-14.30	*Lunch*
14.30-15.00	**Session XI: Summary**
14.30-15.00	**Summary of Discussion 3: ASMs, Verification & Web Interoperability** **Klaus-Dieter Schewe** (SCCH, Hagenberg, Austria) **Elvinia Riccobene** (Polytechnico di Milano, Milan, Italy)
15.00-16.30	**Session XII: Final Summary**
15.00-16.30	**Discussion of Results and Further Steps** **Bruno Buchberger** (RISC, Hagenberg, Austria) **Temur Kutsia** (RISC, Hagenberg, Austria)
16.30-17.00	*Coffee / tea break*
17.00	*end of workshop and departure*

5. Final list of participants

1. Yamine Ait-Ameur, Ecole Nationale Supérieure de Mécanique et d'Aérotechnique, France
2. Paolo Arcaini, University of Milan, Italy
3. Armin Biere, Johannes-Kepler-University Linz, Austria
4. Egon Börger, University of Pisa, Italy
5. Anne Brüggemann-Klein, Technical University of Munich, Germany
6. Bruno Buchberger, Johannes-Kepler-University Linz, Austria
7. Alessandra Cavarra, University of Oxford, UK
8. Adrian Craciun, West University of Timisoara, Romania
9. Elena Ferrari, University of Insubria, Italy
10. Vincenzo Gervasi, University of Pisa, Italy
11. Tudor Jebelean, West University of Timisoara, Romania
12. Gerti Kappel, Technical University of Vienna, Austria
13. Meike Klettke, University of Rostock, Germany
14. Temur Kutsia, Johannes-Kepler-University Linz, Austria
15. Florina Piroi, West University of Timisoara, Romania
16. Nikolaj Popov, Johannes-Kepler-University Linz, Austria
17. Pasqualina Potena, University of Bergamo, Italy
18. Andreas Prinz, University of Agder, Norway
19. Alexander Raschke, University of Ulm, Germany
20. Elvinia Riccobene, University of Milan, Italy
21. Judit Robu, Bolya University Cluj, Romania
22. Patrizia Scandurra, University of Bergamo, Italy
23. Gerhard Schellhorn, University of Augsburg, Germany
24. Klaus-Dieter Schewe, Software Competence Center Hagenberg, Austria
25. Martina Seidl, Johannes-Kepler-University Linz, Austria
26. Bernhard Thalheim, Christian-Albrechts-University Kiel, Germany

6. Statistical information on participants

The age bracket ranged from mid twenties (PhD student) to around 70 years (Emeritus Professor). The majority of participants was in their fourties or early fifties. No exact data regarding age was selected.

Out of 26 participants 10 were female, 16 male. The distribution to countries was as follows: Austria 7, Italy 7, Germany 5, Romania 4, UK 1, France 1, Norway 1.