SOAMED Coherence Report 2012

The SOAMED Ph.D. students

November 26, 2012

1 The big picture

The graduate school SOAMED centers around the idea of introducing theoretically well-founded service-oriented concepts to health care systems and medical devices. This approach aims at a decisive improvement of concepts, methods, and tool support for service-oriented system construction. Currently, seventeen Ph.D. students and eleven supervisors contribute to and participate in SOAMED.

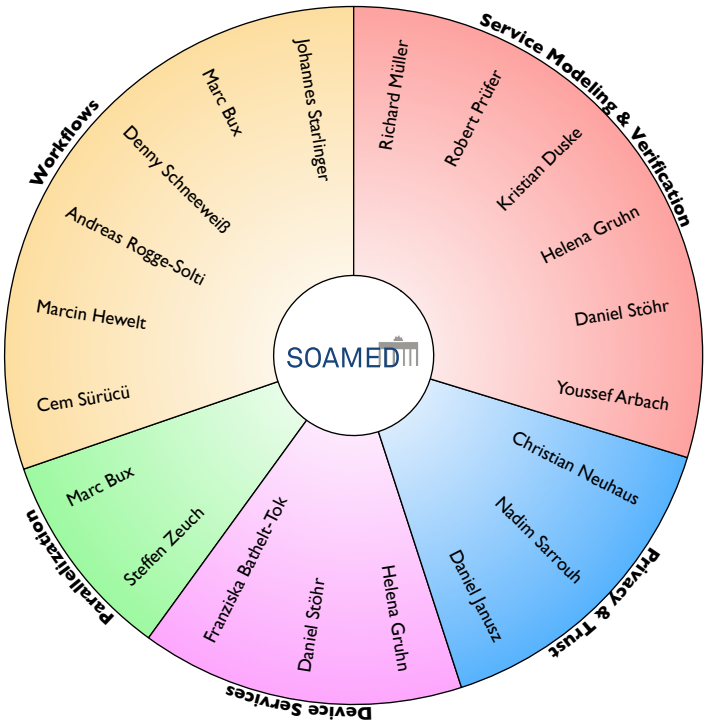

Figure 1: The fields of interest of the SOAMED Ph.D. students.

For a better overview of the research of the Ph.D. students, we coarsely classified their fields of interest into five parts; that is, (1) service modeling & verification, (2) privacy & trust, (3) device services, (4) parallelization, and (5) workflows. See Fig. 1 for a visualization. The modeling and verification of health care services is in the field of interest of Robert Prüfer, Richard Müller, Kristian Duske, Youssef Arbach, Helena Gruhn, and Daniel Stöhr. Nadim Sarrouh, Christian Neuhaus, and Daniel Janusz investigate privacy and trust in service-oriented systems. Helena Gruhn, Franziska Bathelt-Tok, and Daniel Stöhr focus on service-oriented concepts for medical devices. Parallelization of computationally intensive tasks in the medical domain is the shared topic of Steffen Zeuch and Marc Bux. Finally, Andreas Rogge-Solti, Denny Schneeweiss, Cem Sürücü, and Marcin Hewelt are involved in research about health care workflows in general, whereas Johannes Starlinger and Marc Bux specifically target scientific workflows.

The seventeen Ph.D. students can be split into two generations according to when they started their research in SOAMED. In order to support mentoring of the second generation by the first generation, we have established a voluntary SOAMED Ph.D. students meeting at the Humboldt Graduate School since the middle of 2011, which takes place twice a month. The Ph.D. students meeting gives all students the opportunity to closely cooperate in related topics, talk about papers or important contributions to the idea of SOAMED, practice presentations for upcoming workshops or conferences, or administrate their teamwork in general. Moreover, students of both generations attend various soft skill courses as a group, further promoting solidarity.

In the following, each Ph.D. student gives a brief overview of how his research integrates into the big picture of SOAMED, and describes ongoing or planned cooperations with other SOAMED Ph.D. students. A report of Marcin Hewelt is absent, since he joined SOAMED as recently as October 2012.

2 Individual cooperation reports

2.1 Franziska Bathelt-Tok

The research topic of Franziska Bathelt-Tok's dissertation deals with the question how the interoperability between various medical devices can be enabled. In particular, the main focus of the dissertation lies on the fully automated adapter synthesis for data-dependent services.

Hence, this topic is closely related to the topic of Robert Prüfer. Franziska Bathelt-Tok as well as Robert Prüfer focus on the question how to ensure correct interactions of data-dependent services. Both approaches are based on variants of high-level Petri nets and add data to the formal models. While Robert Prüfer focuses on the modeling of data-dependent services such that they interact correctly by construction, Franziska Bathelt-Tok deals with the question how an adapter can be synthesized automatically and correctly if the services are data-dependent.

Because Helena Gruhn and Daniel Stöhr are also working on device services, there is a weak correlation to the work of Franziska Bathelt-Tok.

Currently, the Ph.D. students Helena Gruhn, Daniel Stöhr and Franziska Bathelt-Tok are supervising a seminar that focuses on research topics within the service-oriented domain. [1].

2.2 Helena Gruhn

Helena Gruhn focuses on the modeling and verification of dynamic service-oriented sensor-actuator networks. Her primary goal is to verify correct network behavior after topology changes at runtime. This could be the connection of a new node or the removal of a link. Her work is related to the approaches of Richard Müller and Kristian Duske.

There exist common ground with the dissertations of Franziska Bathelt-Tok and Daniel Stöhr concerning the issue of interoperability of medical devices. While Helena Gruhn researches the specifics of services in resource-restricted sensor-actor networks, Daniel Stöhr investigates the interaction of device services on a control flow level and Franziska Bathelt-Tok on a data flow level.

Furthermore, a joint case study is performed together with Daniel Stöhr in the surroundings of the geriatrics group of the Charité. We are modeling and extending a driver assistant system for elderly people. The system can react on sudden events, e.g. a heart attack, by actuating an emergency brake.

Currently, Franziska Bathelt-Tok, Daniel Stöhr and Helena Gruhn are supervising a seminar which focuses on current SOA research topics.

2.3 Daniel Stöhr

The topic of Daniel Stöhr's work is the "Automated Composition of Timed Services for Synchronizing Medical Devices". The aspect of timed services is related to the works of Kristian Duske and Richard Müller, while the aspect of device services is related to the works of Franziska Bathelt-Tok, Kristian Duske, and Helena Gruhn.

The link between Daniel Stöhr, Kristian Duske, and Richard Müller is the analysis of formal service models containing timed properties. However, the focus of Daniel Stöhr's work is on the generation of service compositions described as timed automata. In contrast, the other two works deal with how services, represented as timed petri nets, can be analyzed regarding properties like controllability, correctness and conformance.

[1] `http://tinyurl.com/czc3sjy`

Moreover, Kristian Duske and Daniel Stöhr perform a joint case study at the Charité Berlin, where they model devices taking part in a diagnostic procedure for congenital hyperinsulinism.

Another joint case study is performed together with Helena Gruhn in the context of the SmartSenior project within the geriatrics group of the Charité. Here, we model a use case where patients with a high risk of heart stroke are monitored while driving. If the patient's health parameters are critical, the monitoring system can take steps against the risk of car accidents.

Finally, device services are an interlink to the works of Franziska Bathelt-Tok and Helena Gruhn. While Daniel Stöhr investigates the interaction of device services on a control flow level, the former deals with device services on a data flow level. The latter examines the specifics of device services in sensor-actuator-networks. All three Ph.D. students are supervising together a seminar on recent SOA research.

2.4 Kristian Duske

Kristian Duske's research focuses on runtime correctness verification. Specifically, the goal of his work is to develop a method to verify deadlock freeness of a timed service composition at runtime. Since this dissertation is in the area of formal verification, it is related to the works of Helena Gruhn, Daniel Stöhr, Richard Müller and, to a lesser extent, the work of Robert Prüfer. The problem of medical device interoperability provides a good application for run-time correctness verification, so this work is also related to the topic of Franziska Bathelt-Tok. There is a close link between Daniel Stöhr's work and Kristian Duske's work because both deal with timing properties of services.

Kristian Duske has also worked closely with Richard Mülller on the topic of timed services. Together, they have published a paper at the ZEUS Workshop 2012 that surveys approaches on the verification of timed services. Furthermore, since both Richard Müller's and Robert Prüfer's work is based on Petri nets, there are many opportunities to cooperate further in the future.

In June 2012, Daniel Janusz and Kristian Duske organized the the annual meeting of the DFG research training groups at Schloss Dagstuhl.

2.5 Robert Prüfer

The topic of Robert Prüfer's dissertation, "Scenario-based Design of Data-dependent Services", is closely related to the topic of Franziska Bathelt-Tok. Both topics generally deal with the problem of how to ensure correct interaction of data-dependent services on the level of formal models. In both approaches, variants of high-level Petri nets serve as an underlying formalism. While Franziska Bathelt-Tok deals with the question how to

synthesize an adapter that ensures correct interaction of data-dependent services, Robert Prüfer focuses on the question how to model data-dependent services in a way that they interact correctly by construction.

Further, as the technique developed by Robert Prüfer is based on Petri nets, there are similarities not only to the topic of Franziska Bathelt-Tok, but also to the topics of Richard Müller and Kristian Duske. Consequently, all of these Ph.D. students benefit from the knowledge and insight the others gain working with Petri nets.

2.6 Cem Sürücü

The process modeling of the medical treatment in the case studies mentioned below is rigid up to now and has to be adapted to real-life, dynamic terms and conditions of the individual treatment. The aim of Cem Sürücü's graduate thesis is to analyze and to extend existing methods of information technology, which can be utilized for the individualization of treatment processes and to achieve the ability for chronological and content-sensitive dynamic sampling as well as adaption to changing influences for a successful process modeling.

In this context Cem Sürücü uses case studies in the fields of interdisciplinary stroke and rheumatoid arthritis treatment. Nadim Sarrouh also examines acute stroke treatment and stroke-rehabilitation. Therefore, there is current communication on the case study and prospects of cooperation. There might be the opportunity to integrate Nadim Sarroug's formal modeling and Cem Sürücü's adaptive process modeling intention.

Further coherence exists to the work of Denny Schneeweiss, who develops a concept for a dynamic time- and resource planning system which allows adaptive re-planning during the treatment process. This depicts another opportunity to expand the scope of work within Cem Sürücü's thesis.

2.7 Youssef Arbach

Youssef Arbach is working on the same topic as Nadim Sarrouh: Dynamic Coalitions (DCs). The difference is that Youssef Arbach is dealing with the problem or phenomenon of DC formation and creation. This phenomenon holds all the dynamics of such coalitions, i.e., it holds the key feature. On the other hand, Nadim Sarrouh is working on the privacy problem of DCs. The use cases start from the medical sector, e.g., from the emergency room, ambulance, stroke unit etc.

Since both researches work on formalizing the problems they have at hand, there is a need to unify the formalisms they use, and to merge their work together to complement each other's work. From this perspective, the cooperation between both has evolved in every step to keep the common part as big as possible. That also involves their common supervisor in this process to pay extra effort to coordinate between the two's work.

On the other hand, and after a deep analysis to the phenomenon of DCs and their formation, there is an overlap with Processes. That pushes Youssef Arbach to communicate with all other students dealing with Processes, at least abstractly. Additionally, Youssef Arbach is coordinating with other people, like for instance Robert Pruefer and his supervisor Prof. Reisig, who are dealing with similar kinds of formalisms to the one he is using (e.g., Petri Nets) to gain a mature overview on related work.

2.8 Johannes Starlinger

Johannes Starlinger's research targets the establishment of similarity measures for Scientific Workflows. The research area of Scientific Workflows is shared with Marc Bux, a Ph.D. student from the second generation of SOAMED students, who is exploring parallelization and distributed execution of these workflows. The interlink between both topics not only resides in the common object of study. It is also reflected in the application of Scientific Workflows to any problem requiring large scale computation. As a consequence, Marc and Johannes co-supervised a seminar held during the summer term 2012 which dealt with the problem of large scale data analysis[1], including the use of scientific workflows in general, and the specific questions arising from their application to large scale scenarios.

Closely related to Scientific Workflows are the fields Business Workflows and Business Process Models, investigated by SOAMED student Andreas Rogge-Solti. Similarity measures for Business Workflows have seen great scientific interest already and the methods developed for them, while not being directly transferable to scientific workflows, provide some interesting ideas for Johannes Starlinger's endeavors.

2.9 Marc Bux

Marc Bux investigates adaptive scheduling techniques for executing data-intensive scientific workflows on heterogeneous distributed resources, such as compute clouds. Scientific workflows are high-level compositions of sequential and concurrent data processing tasks. Increasingly large amounts of data produced in most fields of scientific research along with the maturation of cloud computing technology have led to a demand for strategies towards distributing workflow execution among several compute resources with possibly instable performance.

This research topic is most closely related to the work of Steffen Zeuch, Johannes Starlinger, and Denny Schneeweiss, who are also doctorate students in SOAMED. Steffen Zeuch researches parallelization from a multicore perspective, which shares many fundamental ideas with parallel execution of scientific workflows. On the other hand, Johannes Starlinger focuses on similarity measures for scientific workflows, which overlaps with Marc Bux's topic in the underlying computing paradigm of scientific workflows. Denny

[1] `http://tinyurl.com/d7ancgc`

Schneeweiss researches resource planning of treatment processes in clinical environments, the approaches to which are closely related to adaptive workflow scheduling.

Beyond aforementioned intersections in research topics, which have repeatedly led to fruitful discussions, Marc Bux has co-organized two workshops with other SOAMED doctorate students in 2012. Together with Prof. Dr. Ulf Leser and Astrid Rheinländer, Johannes Starlinger and Marc Bux have been coordinating a seminar on large scale data analysis in the summer semester of 2012. Furthermore, Marc Bux co-planned a GMDS / GI interdisciplinary workshop titled "Service-oriented Architectures in the Healthcare Domain" together with SOAMED doctorate students Richard Müller and Christian Neuhaus[1]. The workshop was accepted by the GI yet had to be canceled due to a lack of submissions.

2.10 Steffen Zeuch

Steffen Zeuch's research deals with Multicore and the Map/Reduce paradigm. The working title is *Bringing Map/Reduce and Multicore together*. Both technologies try to further speedup the computation of big datasets by parallelizing them on different units. The units can be cores of the same processor or different physical separated computers in a network.

This research area is most likely shared with the approach of Marc Bux, another Ph.D. student from the second generation of SOAMED, who deals with parallelization from the workflow point of view.

Furthermore this research task will interfere with Daniel Janusz within the new founded *Mobility Lab* in the database research group. The target of this lab is to evaluate the SOA technologies for the mobile area. Because modern cellphones consist of multiple processors and cores, this will be another area of application for Multicore technologies.

The first Project in the Mobility Lab will be the plunge detection with smartphones. This project will take place in conjunction with Daniel Janusz. He will investigate the privacy related issues and I focus on the data processing and plunge detection. We develop a first prototype, which gather the information provided by the smartphone and visualize them graphically.

2.11 Andreas Rogge-Solti

Andreas Rogge-Solti is working on business process intelligence methods in the health care domain with a focus on process monitoring in non-automated environments. His work deals with different questions that arise, when not all state changes are reported to the monitoring system. When a nurse forgets to document a treatment step, still

[1] `http://gi2012.soamed.de/`

some probabilistic answer can be provided, when the treatment step was most likely to happen.

Currently, A. Rogge-Solti has implemented a first approximation for the unobserved parts in a process. The plan is to integrate this work into the planning method devised by Denny Schneeweiss (Sec. 2.13). By traversing the more probable branches of the search tree first, more realistic plans would be found earlier by the constraint-solver. By doing so, we hope to achieve an improvement over traditional search heuristics.

2.12 Richard Müller

Best engineering practices suggest specifying a system before actually implementing it. Both the implementation as well as its specification have behavioral properties. Conformance checking is deciding whether the implementation of a system preserves a certain behavioral property of its specification. This is the central scientific problem of Richard Müller's thesis.

Conformance checking on formal models of services coincides with service substitutability. Service substitutability and functional correctness - the research topic of Kristian Duske - closely related. Thus, there are many opportunities for future cooperation. Kristian Duske and Richard Müller surveyed formal models for timed services, which has been published at ZEUS 2012 [1].

Finally, Daniel Janusz and Richard Müller supervised a seminar on SOA held during the summer term 2012[1].

2.13 Denny Schneeweiss

The focus of Denny Schneeweiss' research is constraint-based planning and scheduling of human centric workflows in medical environments. Therefore, it is associated with the Workflows-area of SOAMED.

Medical treatments and related activities like preparation and cleaning-procedures can be seen as workflows or processes that can be modeled in workflow languages like the *Business Process Model and Notation* (BPMN). The main goal of this work is a transformation that converts these process models into Constraint-Satisfaction-Problems (CSPs). A constraint-solver can then read these CSPs and calculate a plan that allocates the process activities to the medical staff and resources (rooms, medical devices) in an optimal way.

Cem Sürücü works on concepts to adapt treatment processes to the individual needs and medical conditions of patients. This methodology could benefit from enhanced scheduling and resource-planning of treatment activities.

[1] `http://tinyurl.com/bopb7on`

There also exists a connection to the research of Andreas Rogge-Solti which deals with the probabilistic estimation of process status and process monitoring in medical facilities. In such environments a process monitoring system can only gather sparse information which is mainly generated by the medical staff. The informations and projections inferred by this model could be used to enrich the CSPs generated by D. Schneeweiss' transformation. This would help a constraint-solver to find the plans, that are most likely, faster. A collaboration to integrate both approaches is planned.

2.14 Daniel Janusz

Daniel Janusz is working on *privacy-preserving query execution in medical workflows*. If a new medical workflow at hospital involves data exchange or automatic data processing, the workflow must to be approved by data protection officers. In general, privacy concerns arise whenever personal data is exchanged across company borders. This approach aims to handle these concerns by generating alternative privacy-preserving workflows. Thereby, a protocol was developed, that enables health care provider to query remote data sources about a specific patient.

The work of Christian Neuhaus and Daniel Janusz complement one another, as the protocol developed by Daniel Janusz can run on top of Christian Neuhaus' cloud infrastructure. Another cooperation within SOAMED currently starts with Steffen Zeuch in the context of a new *Mobility Lab* at Humboldt University. With the Mobility Lab we will simulate *ambient assisted living* scenarios, which includes automatic privacy-preserving processing of so-called big data.

In 2012, Daniel Janusz and Kristian Duske are organizers of the annual meeting of the DFG research training groups that will take place at Schloss Dagstuhl[1]. Moreover, Daniel Janusz and Richard Müller are supervising a seminar on SOA held during the summer term 2012[2].

2.15 Christian Neuhaus

The topic of Christian Neuhaus' dissertation is *Quantitative Analysis of Security and Availability in Service-based Software Systems*. The motivation of this topic is the current shift from local to cloud resources for computation and storage needs. As medical applications are highly sensitive with regard to data privacy and system availability, using cloud resources poses challenges and risks. Key to engineering of such software systems is the recognition and mitigation of these risk during the design phase. This dissertation investigates reusable software techniques to improve security properties. Calculation models derived from reliability engineering are then applied to analyze the security properties of the resulting system.

[1] `http://dagstuhl2012.soamed.de/`
[2] `http://tinyurl.com/bopb7on`

The work of this thesis touches the work of Nadim Sarrouh, who is regarding access control in distributed scenarios from a formal perspective. The cooperation resulted in the identification of a formal model, which can be used to implement access control based on user interaction history in distributed systems. The work also touches the one of Daniel Janusz, who develops privacy-preserving communication protocols.

2.16 Nadim Sarrouh

Nadim Sarrouh's research deals with the creation of a formal modeling framework for privacy-sensitive dynamic coalitions. Since privacy is an important topic in the development of service-oriented architectures as well as in medicine, there are various researchers investigating this field from different perspectives, such as Christian Neuhaus and Daniel Janusz.

The closest coherence is to be found with Youssef Arbach, who works on formalizing the creation of dynamic coalitions.

One of N. Sarrouh current case studies in the medical field, is the rehabilitation process for stroke patients at Charité Berlin. Cem Sürücü is also working at that case and therefor in close exchange with N. Sarrouh. There have been several talks to integrate the formal modeling approach of N. Sarrouh with C.Sürücü's efforts to create a machine learning tool in the ambulant treatment sector, which can be seen as a dynamic coalition too. Further possibilities or cooperation are currently investigated.

Christian Neuhaus investigates trust-based access control mechanisms in cloud-scenarios. Trust-based access control is also proposed by Nadim Sarrouh to provide the means to control access in highly dynamic coalitions. A common case study for a trust-based research exchange platform is currently envisioned under supervision of Dr. Med. Blankenstein.

References

[1] Duske, K., Müller, R.: A survey on approaches for timed services. In: Proceedings of the 4th Central-European Workshop on Services and their Composition (ZEUS) (2012)