Guest Scholar Visit at University of Colorado at Boulder
CUGS Travel Report

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Abstract

During a three month period in the spring of 2008, David Broman visited Jeremy Siek at University of Colorado at Boulder, USA. In this travel report David gives a short overview of the background and purpose of the stay, an informal overview of the stay, the main research activities and results, as well as reflections and experiences about the visit in general.

1. Introduction

During the first two and half years of David's PhD program, the research has been focused on semantic aspects of equation-based object-oriented languages in general, and the Modelica language [5] in particular. The aim has been to develop a formal semantics of a core of such a language, to enable more precise language reasoning and to carry out certain mathematical proofs of properties of the language.

In the fall of 2008, David defended his licentiate thesis[1]. In this thesis [3], a formal operational semantics was presented for a kernel language of an EOO-language. A prototype implementation of the language's dynamic semantics was developed, and it was shown that models of e.g., mechatronic systems could be developed in the language. However, formal proofs of important properties of the language, e.g., confluence [1] and type soundness [8], were still to be given.

Jeremy Siek is an assistant professor currently located at University of Colorado at Boulder. His research concerns generic programming and programming language design, particular in the area of type systems. A distinguishing feature of his work is his use of the proof assistant Isabelle/Isar [6, 7] to rigorously formalize and prove properties of languages, such as type soundness.

David and Jeremy have met at several international conferences during the last couple of years and have seen several interesting areas of research cooperation.

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[1] A licentiate degree is a Swedish academic degree, which includes a licentiate thesis and is normally defended half way to PhD degree.

1.1 Purpose of the Visit

The purpose of the guest scholar visit at Boulder can be divided into the following sub-goals:

- To be trained in mechanized techniques of formal proof techniques in general, and to learn and master the proof assistant Isabelle/Isar in particular.
- To further develop the formal semantics of the modeling kernel language [2].
- To establish a close connection with Jeremy Siek and his research group for future cooperation and publication.

2. The Visit

In the following section, I give a short and informal overview of the visit in general.

2.1 University of Colorado at Boulder

The campus of University of Colorado at Boulder is located at the center of the fairly small and beautiful town of Boulder, Colorado. The university is one of the highly ranked universities in USA and has in the recent years received several Nobel prizes.

Figure 1. The Boulder campus is located just a few miles from the Rocky Mountains.

Figure 2. The engineering building, which hosts the department of Electrical and Computer Engineering.

The campus is located at walking distance from the Rocky Mountains (see Figure 1), which offers various outdoor activities. The campus area has unique architecture with buildings made out of red rocks. The only exception is the engineering building (Figure 2), which is mainly built of concrete. This is the building where the department of electrical and computer engineering is located and where I spent most of my time.

2.2 Working in the Research Group

During my three month stay, I was working in Jeremy Siek's research group. I got my own little cubicle (Figure 3) in the same room as the other PhD students in the group. Since the room lacked windows, we were never disturbed by the nice Colorado weather. Hence, it was of course much easier to focus on the research.

There was a good atmosphere in the group and several of the other PhD students were working with

Figure 3. My small personal office cubicle where I spent many productive hours. Please notice the bottle of Mountain Dew to the right hand side, which kept me focused for hours.

research areas which were interesting and somewhat connected to my interest of semantics and type system. Joe Angell is working on gradual typing, Geoffrey Belter on high-level optimization of linear algebra and Datalog, and Weiyu Miao on generic programming and meta-programming.

Even though most of the time was spent within the group, I also met several other people from other parts of the department. It was especially pleasant to meet and have daily chats with Graham Price in Manish Vachharajani's group.

2.3 The Life Outside the Engineering Building

The main reason for choosing Boulder as the university to visit was the collaboration with Jeremy. However, Boulder turned out to be a very nice choice even from a personal and private point of view. During the stay, my wife and our less than one year old daughter were also appreciating the friendly atmosphere of the town.

It was fairly easy to find a good place to stay, since we could rent an apartment via the university's family housing service. The apartment was perfectly located in the center of the town, close to the Boulder creek that crosscuts the city.

During the weekends we were often doing small trips around the state. We were especially appreciating the large number of trails (Figure 4) available in the mountains; some of them starting just a 15 minute walk from where we lived.

Boulder is a young town with a clear trace of student life. There were always activities going on, where one of the largest event was the 10km running competition Bolder Boulder (Figure 5). The whole family was joining this spectacular event together with the other 50000 runners. I was running, while my wife was walking with our daughter in a backpack.

3. Research Activities and Results

During the stay, I was working with research directly connected to my thesis work. I had a close collaboration with Jeremy including at least one scheduled supervisor meeting every week.

3.1 Isabelle / Isar

Initially, most of the time was spent on getting familiar with the Isabelle/Isar proof assistant environment and the techniques and principles of mechanized formal proofs. Together with the other PhD students in the group, I was following a seminar series about Isabelle/Isar and proofs of formal semantics. This series, given by Jeremy, was a compressed version of a PhD course CSCI 7000-000: *Practical Theorem Proving with Isabelle/Isar*, which was given the year before. During this time I learned about different proof methods, es-

Figure 4. Hiking with my daughter and wife in the Rocky Mountains was one of the main activities during the weekends.

pecially how to make type soundness proofs on typed lambda calculuses defined with small-steps semantics.

3.2 Types Course

During the spring, Jeremy was teaching a PhD course on *Types and Programming languages*. I was not formally taking part of the course, but joined in on the lectures. However, I learned several things during this course, where the lectures on *System F* and termination proofs of *syntactic unification* were especially interesting and instructive.

3.3 Development of Formal Semantics

Initially, we focused on how to purify the physical flow lambda calculus [2], i.e., to encode the semantics without effects. This lead us to explore new encoding techniques based on ideas given in Felleisen and Hieb's classical paper [4].

During this work process, several meta-theories were also discussed and analyzed. Especially encoding schemes for name binding together with Isabelle/Isar were considered in detail.
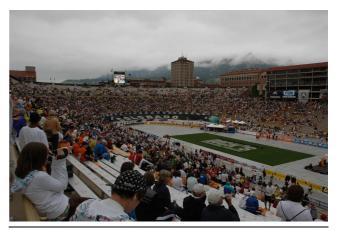

Figure 5. The Bolder Boulder running race finished at the Folsom stadium. This year's race celebrated 30 years with surprisingly rainy weather.

A new preliminary semantics was developed during this time, including a new approach with meta-programming capability. Moreover, we were further exploring the approach of using Isabelle's functional package to define the semantics using total functions. This approach has the benefits of both defining a semantics to which proofs can be carried out and at the same time generating an executable interpreter for the prototype language.

3.4 Future Collaboration

The three months stay was very rewarding, but turned out to be quite short. However, instead of just being a short project work, the visit became a start of a future collaboration between me and Jeremy. During the stay, Jeremy also accepted to be my co-supervisor. Hence, we are planning to finalize the development of the formal semantics during the rest of my PhD, and to collaborate on future publications.

4. Reflections and Experience

The visit in Boulder turned out to be a very pleasant time both for me professionally and for my family from a private perspective. In the following two sections, I give a brief summary of reflections and experiences, which might be useful for other PhD students going abroad.

4.1 Professional Perspective

The main reflections from a professional perspective are:

- It is important to be well prepared and very clear on what should be the main goals with the visit. My main goal of being trained in mechanized proof techniques was fairly successful, since this work started from day one of the visit.
- Do not try to do too many things during the stay, i.e., focus on a few goals that you want to achieve.

Looking back, maybe more time should have been spent on formalization of the new semantics in Isabelle/Isar, and less time on investigating different encoding techniques.

- It is a good thing to see a short visit like this one as a start of a collaboration, and not necessarily just a one time project.
- Seriously consider to have a longer stay. Three months was too short; especially when both the research atmosphere and the town were so pleasant.
- Going abroad and doing a guest scholar visit is especially suitable to do after licentiate degree or similar. It is late in the process enough to really know what you are doing, but still early enough so that a rewarding visit can boost your research.

4.2 Private Perspective

The main reflections from a private perspective are:

- Contact the university regarding housing. Many of the universities in USA have specific areas for housing and special accommodation for guest scholars with families.
- Doing a guest visit while the wife / husband is on maternity leave is both rewarding for the family and practical, since it is hard to find jobs for such a short time.
- Start to apply for US VISA very early. Typically, you need papers from the university you are visiting before you can apply for a VISA.
- Take the time off after the research visit and see the country. After the research period, we had three and half weeks of vacation, doing a spectacular road trip from Colorado, over the Rocky Mountains and via the amazing national parks in Utah. After visiting the Grand Canyon and Las Vegas, we passed by the major cities in California and finally flew back to Sweden from San Francisco. A wonderful trip that is highly recommended.

5. Conclusions

In this travel report I have described my guest visit at University of Colorado at Boulder. It turned out to be a very pleasant and rewarding visit. During the stay, I learned especially about mechanized proofs and many tips and tricks in Isabelle/Isar, which would have been very hard to learn without expert help. Moreover, instead of seeing this visit as a separate project, it became a foundation for future collaboration. During the stay Jeremy Siek accepted to be my co-supervisor, which looks promising for future collaboration.

References

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