

Rewriting Techniques and Logic Programming Report on a Visit to ICOT

Pierre LESCANNE
Centre de Recherche en Informatique de Nancy
INRIA-Lorraine
Nancy, France

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1 Introduction

The Research Center of ICOT invited me at the Institute for New Generation Computer Technology under the proposition of the director of INRIA and I am pleased to report in this note what I learned and what I have done during this three week stay. Before entering into details, I may say that the visit was really successful and I had many interactions with researchers.

My domain of research is clearly oriented toward *Automated Deduction* and especially to *Rewriting Techniques*. Therefore, my place was naturally in the group of Doctor Sakai and Doctor Ohsuga whose main interest covers essentially these domains. Obviously, I am curious of *Logic Programming*, therefore *Horn Clause Programming*, but also of all kinds of programming that specifically deals with a logic language, namely *Equational Logic*, *Higher Order Logic*, *Higher Order λ -calculus*, *Intuitionistic Logic* etc. Indeed, my first interest for this field started in May 1974 when I attended at Amsterdam a spring school on Foundation of Computer Science, where Professor R. Kowalski, from Imperial College gave lectures on *First Order Predicate Calculus as a Programming Language* and where he presented the first bases of the language PROLOG and in October of the same year when I attended talks given by Professor A. Colmerauer. Later, as a part of my PhD, I was working in algebraic or equational specifications of Abstract Data Types and I tried to write an interpreter for a Horn clause language with equalities and I realized the difficulty of introducing them in a resolution based theorem prover or programming language and I decided to focus essentially on this aspect and to work mostly on Equational Logic. At that time, I learned about the *Knuth-Bendix Completion Procedure* which as many people pointed out is strongly connected with resolution in Equational Logic, more precisely with *paramodulation*. From this experience, I learned that the different kinds of logic programming are complementary and should work together. This previous comments show how deeply and how long I was interested in visiting ICOT, since I never had the opportunity to speak with a researcher of this Institute before. This also tells why I was interested to compare the approaches of Horn Clause Programming and Equational Logic. As the manager of the REVE project, I wished to see the collaboration between practice and

theory. This makes clear that my place was at the First Laboratory.

During the first day, I was welcomed by Doctor Iwata from the Research Planning Department. He introduced me to Doctor Hiroshige the executive director, to Doctor Fuchi Director of the Research Center, Doctor Furukawa Deputy Director of the Research Center, Doctor Ito chief of the First Laboratory and chief of the Third Laboratory¹, and to Doctor Uchida chief of the Second and Fourth Laboratory. He also presented me an overview of the ICOT through a well done video tape and we set some technical and low level details. Then through Doctor Iwata I got in touch with Doctor Ohsuga who, as my main host, took in charge all the details of my life at the Mita Kokusai Building.

2 Presentation of ICOT Researches

Quickly, I had a presentation of softwares made at ICOT essentially in the group called *Computer Aided Programming* that I am going to refer as *CAP* as the researchers here do. I started with a presentation of *Metis* by Doctor Ohsuga. I was especially interested in this program since I wanted to see its relationship with our MIT-CRIN project *REVE* and I enjoyed during the rest of the three weeks to run examples showing interesting behaviors of this PROLOG based software. I had also a demonstration of *CAP-LA* a theorem prover for Linear Algebra by Doctor Fujita from Mitsubishi Research Institute Inc. *CAP-LA* is able to solve problems of elementary linear algebra at the level of a senior high school student or a freshman college student. I was delighted by this demonstration. I was also introduced by Doctor Aiba to the interpreter of *T* a functional language based on rewrite rules and to *CAL* an prover for a constraint logic.

I received also a presentation of the activity of the *CAP* group by Doctor Sakai and I discovered that we have more interest in common than I expected, namely in constructive logic and computer algebra. Indeed, I learned that an activity in this domain is starting, namely an implementation of an algorithm for computing *Gröbner bases* and a project of implementation of the *Collins cylindrical method* for quantifier elimination in real fields. This problems are important in my current activity, since we will see later on, I am interested in methods of proofs of termination based on polynomial interpretations.

¹Later I was introduced to Doctor Hasegawa the new chief of the First Laboratory

Introduced by Doctor Furukawa, I had the opportunity to deepen the question I had on *GHC* the *Guarded Horn Clause* language designed by Doctor Ueda. This is a nice language for parallel programming with many interesting features which seem to bridge the former gap between classical languages, say with over-simplification "functional", and those of the PROLOG family and to provide nice tools to implement large softwares like operating systems or expert systems. I got especially excited about aspects of its formal operational semantics, as I am rather inclined to a prescriptive approach to the design of a programming language and my way to understand the semantics of language is both through examples and through a formal description.

In the middle of my stay, I had the opportunity to visit ETL at Tsukuba

invited by Doctor Futatsugi and Doctor Shimada. With the first, I spoke on *Algebraic Specification and Rewriting Techniques* and the second told me about *Data Flow Architectures*.

3 Presentations at ICOT

My host Doctor Ohsuga set a tight schedule of lectures and informal seminars. The first lecture, given on Monday July the 13th, was about *Current Research Status in Term Rewriting Systems* and I was also asked to give a survey of the *Second Conference on Rewriting Techniques and Applications*. My second lecture, given on Wednesday the 22th, was on *Automated Deduction based on Term Rewriting Systems* and I had a large audience of specialists. In both cases, questions from the floor show the interest of researchers in this country for problems in Equational Logic. Let me summarize here why Equational Logic and Rewriting Techniques are so important.

- *Equational axioms are the hard part of Resolution based theorem provers* and no satisfactory and efficient methods exists to handle them other that rewrite rules.
- One needs a *Theory of Simplification* in theorem proving for reducing the search space, but also in *Computer Algebra* a growing domain with many new applications.
- *Equational Specifications* of software rely on Equational Logic.
- *Functional Programming* is a kind of implementation of equational logic. we mention *T*, but also such languages as *ML* or *Hope* use rewriting techniques.
- Rewriting Techniques are tools for a model of *parallelism* and new *architectures* of machines based on rewriting techniques are studied.
- *Techniques of Program Transformation* are nothing but rewriting systems.
- It has been proved recently that *First Order Predicate Calculus* can be efficiently implemented by methods similar to the Knuth-Bendix completion algorithm, taking cleverly advantage of the simplification during the process.

In parallel, I gave informal seminars to Doctor Sakai group on different aspects of automated deduction and rewriting techniques. The three first ones were devoted to *methods for proving termination*, namely to the recursive path ordering, the polynomial interpretation method and to the transformation ordering. Especially, many discussions were about methods for proving the termination of associative and commutative rewriting systems, for which no method except the polynomial interpretations works. The fourth seminar was on deeper explanations on a inference rule called *Collapse*, introduced during my first lecture and that required complements. I also talked about ω -*completeness*, an

important concept in proof by induction in equational theories. The last and fifth seminar was essentially a survey of problems raised during the three weeks. Usually, the discussion was tense and I think I had never so many and so accurate questions in such a short time. This help me to clarify many points. Providing an ordering on open terms which can be extended to a total ordering on ground terms, an important problem in equational theorem proving, pushed me to write a short note (see appendix).

4 Conclusion

The visit was really fruitful not only from a scientific point of view, but also it gave me a better understanding of the Japanese culture, the Japanese way of life and way of working. In my country, many tasks are done individually, here people work always in team and this is especially successful in research. Since it is the way I like to work, I was particularly pleased. I was also impressed by the wish that ICOT people have to transform there research in industrial products and I am sure that this is a reason of the success of this Institute. This success makes indeed no doubt for me. Concerning my stay, I feel that such exchanges are really useful and I hope that others will take place in the future in both directions.

I would like also to emphasize on the quality of the welcome I got from people here. My wife and I were invited really often. I would like especially to thank Doctor Iwata and his wife who invited us for a dinner and a tea ceremony on Saturday the eleventh and for Doctor Ohsuga and Doctor Sato who gave us a ride to Doctor Iwata's house. I am also grateful to Doctor Aiba and Doctor Sakai for an extraordinary visit to Kamakura and Yokohama. In addition, we were invited to a welcome and a farewell party and, during these three weeks, my colleagues Doctor Aiba, Doctor Ohsuga, Doctor Sakai and Doctor Sato showed me the delight of Japanese cooking by leading me everyday at a different restaurant. Finally, I would like to thank Doctor Iwata and Miss Nakamura for everything they did for organizing this so pleasant stay.

English is not my mother language and I apologize for not having precisely enough translated my feeling. I wish I could practice your language that sounds so nice and your writing which is so beautiful to express my gratitude. So as a conclusion, let me say in a few words what I feel really. *Merci infiniment mes amis de l'ICOT, vous m'avez beaucoup appris et je vous en suis très reconnaissant.*