

# Report on Visit to ICOT

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## 1 Introduction

On the kind invitation of Dr. Fuchi (淵さん), I spent the period June 15–June 26 as a guest of ICOT. I was invited to ICOT because of my work on Gröbner bases. Needless to say, I was quite honored to receive, and most pleased to accept, ICOT's very generous invitation to visit.

## 2 Purpose and Results of the Visit

The main purpose of the visit was to improve the efficiency of an existing Gröbner bases program developed at the 4th Laboratory. A detailed technical report describing the latest algorithms, implementation tricks, as well as their mathematical background is the most tangible result of my stay at ICOT.

The main activities of my visit were

- design of a version of Buchberger's algorithm suitable for constraint logic programming,
- to improve the efficiency of the existing implementation,
- explaining my work, and that of my colleagues, to a group of experts,
- discussion with members of the 4th Laboratory regarding their research,
- a talk entitled "Implementation Aspects on Buchberger's Algorithm"
- to write a technical report that covers most of the material in the forthcoming "CLP Handbook"

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### 3 Interaction with ICOT Researchers

During my stay, I had a number of, formal as well as informal, meetings with individual researchers. I discussed the existing implementation of Buchberger's algorithm for the PSI, multi-PSI, PIM/m, and (the soon to be ready) PIM/p machines. Mr. Sawada (沢田さん), who has done most of the implementation, explained the overall structure of the program and described how redundant critical pairs, and the selection of critical pairs is implemented. The heart of every Gröbner bases program is the bignum package. I had many interesting discussions with Mr. Terasaki (寺崎さん) regarding his bignum package. It is a very difficult task to do an efficient implementation in KL1 (the programming language in use at ICOT) and therefore the low-level bignum operations are now supported in micro-code. It is however a sad fact that, despite Mr. Terasaki's (寺崎さんの) careful implementation, even a low-end workstation such as the SparcStation SLC outperforms the existing PSI and PIM machines when it comes to integer operations. This performance gap will probably become larger in the future, since new workstations have hardware support for multiplication. For this reason it will be almost impossible to compete with existing Gröbner bases programs running on ordinary workstations.

Anyone interested in adopting Buchberger's algorithm to new architectures, rather than in raw performance, will find the new PIM/p interesting. This is a shared memory machine, an architecture that is better suited for this type of computations than distributed memory machines such as the multi-PSI (at least if each processor element needs a copy of the full basis during the normal form computation).

After discussions with Dr. Aiba (相場さん) we decided to give up, at least for the moment, the incremental version of Buchberger's algorithm developed here at ICOT. The basic idea behind the incremental version is to add input polynomials (also called rules/equations) dynamically without restarting the computation. Sometimes this polynomial will have more variables/parameters (added by GDCC, *Guarded Definite Clauses with Constraints*) than the original polynomials. This forces us to dynamically change the monomial order. Despite that this is done in a rather intelligent way, it can still cause the monomial order to degenerate into the lexicographic order and result in time-consuming computations. Even in the case where we do not introduce any new variables, it is not at all clear that the incremental version is more efficient. There are good reasons to believe that it is more efficient to start the computation anew with both the original polynomials and the new polynomial as input.

This change also permits us to use vectors of fixed size, instead of lists, to represent monomials. Since vectors are handled more efficiently than lists in KL1, we hope that this change will give a good speed-up.

At the end of my stay, Dr. Sato (佐藤さん) told me about his work on Boolean Gröbner bases and how to detect redundant critical pairs when computing Boolean Gröbner bases.

### 4 Social Events

I was extremely well cared for during my visit.

First, there was an excellent Japanese dinner with members of the 4th Laboratory.

Then, Executive Director Hiroshige (廣重さん) was kind to invite me to a lunch at a high-class Chinese restaurant with the management of ICOT.

I very much enjoyed the yearly ICOT bowling tournament. I had never played bowling before!

### Acknowledgements

First, I would like to thank Dr. Fuchi (渕さん) for inviting me to ICOT, and to the management and directors of ICOT who so graciously supported my visit, and who welcomed me warmly.

I am indebted to Dr. Iwata (岩田さん) and Ms. Karakawa (唐川さん) for making hotel arrangements for me and for assisting me in numerous other ways.

Special thanks to Ms. Higuchi (樋口さん) who helped me to buy three beautiful Japanese knives.

Dr. Aiba (相場さん) and my "office mates" Mr. Sawada (沢田さん), and Mr. Terasaki (寺崎さん) made my visit both fun and productive.

Finally, I have been genuinely touched by the warmth and hospitality of all Japanese colleagues that I met, during and after office hours, and I look forward to further fruitful exchanges with the people at the 4th Laboratory, both on visits to Japan and in Sweden.

# CURRICULUM VITAE

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## Personal Data

- Born September 3, 1962, Stockholm, Sweden
- Status Single, Swedish citizen.

## Education

- 1981 - 1987  
MSc in Engineering, from the School of Physics, having specialized in Applied Mathematics (Civilingenjör, 'Teknisk fysik'), Royal Institute of Technology, Stockholm, Sweden.

## Academic Employment

- 1988 to present  
Graduate Student (PhD Scholarship, "100% Doktorandtjänst"), advisor Prof. Stefan Arnborg

## Other Employment

- 1983 - 1984  
Military Service, Officers' training course for sergeant's rank, Sweden.

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- July 1986 – October 1986  
Research engineer, The Institute of Applied Mathematics, Stockholm, Sweden, Area of work: Computer Simulation
- November 1987 – December 1987  
Servisen AB, Stockholm, Sweden, Area of work: Stock market analysis.
- 1989 to present  
Reviewer and Technical Writer for “Industriell datateknik”, Swedens leading computer magazine.
- 1991  
MathWorks AB, Stockholm, Sweden, Area of work: Marketing and PR.