Report on my Visit to ICOT July 16 to September 15, 1994

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1 Background

In a world where funding for basic research is ever more difficult to find, an institution like ICOT looms large. The research in logic programming and automated theorem proving done here might easily be the world's largest concerted action in these fields. As a researcher whose background is in automated deduction it is natural to be curious for first-hand knowledge on such an enterprise.

Other motivation was more technical: I had so far worked mainly in tableau-based theorem proving. There, implementations based on logic programming have some tradition. Moreover, there is a close relationship between tableau methods and model generation the latter of which is investigated by ICOT's MGTP group. I was interested to learn more about the connections between the tableau/logic programming paradigm and the model generation/concurrent logic programming paradigm.

As I have also done some work in deduction for many-valued logics and the MGTP group is interested in finite domain problems it seemed to be natural to try to transfer some of the insights from many-valued logic deduction to the model generation world—after all, many-valued functions can be conceived as first-order relations over finite domains.

Dr. Hasegawa kindly suggested that I spend two months as a visiting researcher at ICOT during the summer of 1994. I was happy to accept this invitation after the end of my summer lecture term in Karlsruhe.

Let me now give a more detailed account of my activities and experiences during my visit.

2 Activities during my stay at ICOT

2.1 Presentations

I gave two longer, tutorial like talks at ICOT towards the beginning and towards the end of my stay, respectively. The first presentation was an introduction to many-valued logics and deduction in many-valued logics containing some advanced examples of specific techniques for efficient deduction in such logics.

The second talk was on the mutual relationships between tableaux, model elimination, model generation, and linear resolution. Recent work by R. Letz (TU Munich, Germany) showed that clause tableaux constitute a natural and flexible framework for characterizing some of the above mentioned calculi. I extended his approach to SL-resolution and model generation. Notably in the case of model elimination and SL-resolution the tableau formulation is much easier to follow and better motivated than the original formulations.

On August 18./19., Hasegawa-san organized a visit to NTT Research Labs near Nara (Mr. Akahani) and to Mitsubishi Central Research Labs in Osaka (Dr. H. Fujita), during which I gave two more talks based on recent presentations I made at international conferences. Their titles have been, respectively, "On Anti-Links" (joint work with B. Beckert, University of Karlsruhe and N. Murray, A. Ramesh, SUNY at Albany, USA) and "Improving Temporal Tableaux with Arithmetic Constraints" (joint work with O. Ibens, University of Karlsruhe). I had also stimulating discussions with the resident researchers and I was given presentations of their research. I found that notably the "Parthenon" system for hardware verification at NTT Labs is an impressive tool.

From ICOT's part I have been given several very interesting presentations of their current research activities, in particular, this was on the KLIC system, the PIM, HELIOS, and HELIC-II. During the latter presentation I had a very stimulating discussion with Dr. Nitta in which possibilities for an advantageous use of many-valued logic within legal reasoning emerged. Unfortunately, my stay was too short to pursue this interesting possibility

further, but it is definitely a thought worth coming back to.

2.2 Research

My arrangements with ICOT specified either many-valued deduction with MGTP or MGTP for applications in software verification as intended domains of research during my stay. As it turned out, only the first possibility was considered, but on the other hand I did some work that was not anticipated.

The first thing I did was to learn programming in KL1 based on which I went on to acquire a somewhat detailed understanding of the implementation of MGTP and its recent enhancement, CMGTP. I also looked closely at an implementation of the Davis-Putnam procedure based on ideas of M. Stickel (SRI, USA) which is used to a certain extent in the research of the MGTP group.

From here on, my activities split into two threads: it is a kind of folklore that the Davis-Putnam procedure, MGTP, and clause tableaux are closely related, however, nobody seemed to have bothered to write down some of the formal relationships among those inference systems. Therefore, I started to do this to some extent along with some straightforward, but (to the best of my knowledge) new results on relative proof length complexity. The present report is not the place to go into technical details, so I refer to two forthcoming ICOT Tech Reports that will contain this material.

The second strain I followed was motivated by a discussion I had with Hasegawa-san after my first tutorial during which it became apparent that the techniques I had developed for many-valued tableaux, resolution, and the Davis-Putnam procedure can be transferred to model generation and thus be conceived as a natural extension of the ideas already incorporated into ICOT's Constraint MGTP (CMGTP). As already noted, many-valued clauses and rules can be looked upon as well as function-free first-order formulas over finite domains (FD) or simply constraints over finite domains. Consequently, several techniques are common to both worlds, for example, the representation of finite sets as ordered lists of disjoint intervals or extravals (in a finite domain solver one would use unions of direct products of intervals).

In MGTP all disjunctive information on the value of a finite function is handled via case splitting and the underlying logic is classical. Using many-

valued meta connectives a certain amount of disjunctive information can be moved into those meta connectives which leads to a less amount of explicit branching. So-called regular many-valued connectives can be conceived as upset/downset- and ultimately as interval/extraval-based FD constraints over one variable. An extension of CMGTP in this sense provides a compromise between MGTP and an FD solver. In the latter all the complexity is hidden in the updating and bookkeeping of the constraints, there is no case splitting above the constraint level. In an extended version of CMGTP, on the other hand, there is less case splitting than in MGTP, but the constraint updates are still fairly quick, polynomial time operations.

To a certain extent such an approach combines the advantages of both (the MGTP and the FD constraint solver) worlds: we can have the far-reaching control over the solution strategy as expressed in MGTP rules and in the problem formulation written in KL1 and we can have (some of) the data compression capabilities of an FD solver. Moreover, in MGTP finite domain problems can be easily mingled with non-logical constraints. It is conceivable that an implementation of an extended CMGTP in Eclipse Prolog might be faster than in KL1, but there is a parallel implementation available for the second which is a potential that should not be underestimated.

The state of affairs at the writing of this report is that an extended version of CMGTP has been completely specified and its implementation by Shirai-san has started. I am full of hope that this research will lead to a publishable paper as soon as experimental data are available.

3 Assessment

There are two things to be evaluated. First, the scientific success of my specific visit at ICOT, and second, more generally, the ICOT visiting scheme for foreign researchers.

I am leaving ICOT with the good feeling that I could accomplish something during my stay. I did learn a lot about the research done by ICOT and, in particular, at the MGTP group. I broadened, completed, and unified my own perspective on automated deduction, I made contacts to many Japanese colleagues, and generally I could work effectively for two months without being distracted by teaching and adminstrative tasks. Equally important is that I think I could also give something back to the people at ICOT during

many discussions and through the tutorials I gave.

Looking back, I am very glad about my decision to come here and I am grateful to Dr. Hasegawa and Dr. Uchida who made my stay possible.

Now let me come to the assessment of the general visiting scheme.

It is my firm opinion that the foreign visitors program has been extremely important and beneficial for the Japanese as well as for the international research community and, therefore, ultimately for world economy.

Until about ten years ago Japanese researchers were a relatively small and isolated group in the automated deduction community. The existence of ICOT has changed this situation dramatically. If one looks at the program committee of any international conference or at the editorial board of any journal in the automated deduction or the logic programming field one will find some Japanese names, and quite often they are or were members of ICOT. I am sure that a lot of this success goes back to the ICOT visiting program, because it gave so many Western researchers opportunity to know and to appreciate their Japanese colleagues. This point should perhaps be elaborated on a little further.

One could argue that scientific results are communicated through papers and prominent positions should be filled by people who have done eminent things. Alas, things simply do not quite work that way. For once, many people in the East and in the West have done important research and if one has the choice between several equally well suited candidates, then the one who is known personally is likely to get the job, simply because he (or she) represents less unknowns. After my stay at ICOT I can make a well-founded (and positive) judgement on certain aspects of Japanese research. Second, when I invite someone into a program committee, I do not only want to be sure that he or she is an expert in the field, but I need to know as well that I can rely on the quality and promptness of the reports. A personal acquintance is also preferred in this case and a certain knowledge of the candidate's background is important. Third, the communication and dispersal of scientific ideas requires a certain amount of oral communication, sometimes an argument or a persuasion. Before my ICOT experience, on international conferences I "brainstormed" and discussed mainly with Western colleagues, simply, because I knew them better and they were easier to communicate with. Now I am in a position in which I can better understand the ways in which my Japanese colleagues think and work and that makes it easier to integrate their contributions.

The more Westerners know about Japanese research environments the better they are able to evaluate and appreciate the work of their Japanese colleagues. It is often difficult to get an accurate picture of the global achievement that is made by a group out of conference and even of journal papers. In the case of the Japanese the language barrier and the geographic isolation severes the situation considerably. A longer stay in Japan gives one enough background knowledge and understanding of its people so that also future contacts with Japanese colleagues will be alleviated.

Let me close with the sincerely expressed hope that, although ICOT will be terminated soon, there will be more similar actions in the future. I believe that a certain amount of concentrated basic research is essential for the world economy in the long run. It worries me to see that Western economies (including my own and the EC) are redefining more and more research programs from basic reserach into short-sighted application oriented research. Of course, research should lead to applications finally, but my opinion is that it works far more indirectly than most politicians and managers conceive.

With the definition of the FGCS project and the establishment of ICOT together with a generous travel and exchange scheme the Japanese government stated an example for the rest of the world which can only be hoped to find many followers.

4 Suggestions

Being asked to write a "constructive report", I guess I should try to make some suggestions for improvements, although I see very little that really needs improvement.

The main shortcoming I see in the activities of ICOT is a certain lack of usage of the achievements of modern software engineering tools and principles. This does not concern so much management and planning which are quite adequate for a research environment, but documentation and tools.

Most software I saw at ICOT is very sparsely commented (or not at all) and the user manuals have a considerable backlog with respect to the current version. Moreover, most information is only available in Japanese. While the drawbacks of insufficient documentation are obvious, the lack of English documentation somewhat counterfeits the aims of the current FGCS follow-up project which is "dissemination of FGCS technology". For instance, the

KLIC system is an excellent piece of software, but due to lack of documentation and insufficient error messages it is not easy to use. Another example is the MGTP family of theorem provers which is potentially useful for many people, but currently it really can be used only by its developers. This is a severe obstacle if the results of the FGCS project should get the world-wide attention they deserve.

Further minor points in a similar vein are that tools such as source code control systems, makefiles etc. are not consequently used and important auxiliary software (such as Sicstus Prolog, for example) is not always up-to-date.

As there seems to be not so much emphasis in the training of Japanese Computer Science students in the elements of software engineering mentioned above, it might be a good idea to have some sort of in-house training for newcomers with respect to those matters.

These observations are by no means intended to decrease the generally high value of the results achieved at ICOT. Moreover, they hold only for the part of ICOT's research I have had a closer look at. The intention is merely to highlight some potential obstacles with respect to the fulfillment of the specific goals of the FGCS follow-up project.

Let me add a few words on the research performed in the MGTP group. I think that Dr. Hasegawa and his group have made some important contributions towards the goal of controlling the search space in logical deductions which is generally regarded as being of paramount importance. The work on Lazy Model Generation and transformations based on Non-Horn Magic Sets could prove to be important as well outside of model generation. It would, therefore, be most desirable to give this work a stringent theoretical (and thus transferable) and even more lucid presentation. My feeling is that perhaps this fine work is sold a little bit under value so far.

Acknowledgements

Somebody like me who is in Japan for the first time and who cannot speak or read Japanese is potentially prone to many embarrassements and inconveniences. The fact that this did not happen and that, on the contrary, I enjoyed my stay here most thoroughly, must be ascribed to the dedicated staff and researchers at ICOT who never failed to help me in every conceivable way.

I would like to take this opportunity to express my particular gratitude

to a number of people: Dr. Hasegawa and Dr. Uchida made it possible for me to come here. Koshimura-san had the tedious task to take care of me and to teach me the essentials of Japanese culture; many times he joined me for lunch or dinner and would patiently answer a constant stream of questions about Japanese ways and Japanese culture. Transport, accomodation, and many other organizational details were perfectly arranged for by Narita-san and Karakawa-san. I had several fruitful discussions with Dr. Hasegawa, Mr. Koshimura, Mr. Shirai, Dr. M. Fujita (MRI), and Mr. O'Carroll (MRI). The secretaries Ms. Tomonaga and Ms. Yamauchi were invariably friendly and extremely efficient.

Domo arigato gozaimashita!

Curriculum Vitae

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Education

Sep 1968 – July 1972	Elementary School, Winnenden.
Aug 1972 – July 1981	Georg-Büchner Gymnasium, Winnenden.
Oct 1981 – Dec 1987	Study of Computer Science at University of Karlsruhe.
Dec 1987	Diploma in Computer Science from University of Karlsruhe.
Jan 1988 – May 1989	Civil Service at the Rehabilitationsklinik in Karlsbad-Langensteinbach.
June 1989 — May 1992	Research assistant in TCG Project Dept. of Computer Science, University of Karlsruhe (Professor P. H. Schmitt) and IBM Germany, Scientific Center Heidelberg.
May 1992	Ph.D. in Computer Science from University of Karlsruhe.
since June 1992	Research assistant in the DFG Schwerpunkt "Deduktion" at Dept. of Computer Science, University of Karlsruhe (Professor P. H. Schmitt).

Scientific Activities

June 1991	Scholarship for 3rd International School for Computer Science Researchers in Acireale/Italy.
Feb 1992	Scholarship for International Workshop on "Order in Algebra and Logic, II" in Naples/Italy.
Mar 1992	Co-organizer of "Workshop on Automated Theorem Proving with Analytic Tableaux and Related Methods" in Lautenbach/Germany.
Jan 1993	Research stay at State University of New York at Albany and University of New Haven/CT on invitation by Profs. N. Murray and E. Rosenthal.
Apr 1993	Co-organizer of "2nd Workshop on Automated Theorem Proving with Analytic Tableaux and Related Methods" in Marseille/France.

Invited lectures at Reasoning Group, Dept. of AI, University of Edinburgh; Imperial College, London; AI Group at Technical University Munich; Dept. of Computer Science, University of Milan; Dept. of Computer Science, State University of New York at Albany; Institut für Computersprachen, Technical University Vienna; Max-Planck-Institute for Computer Science, Saarbrücken; Dept. of Computer Science, University of Paderborn.

Referee for Journal of Logic and Computation, Journal of Foundations of Computer Science, Journal of Automated Reasoning, several Conferences.

Member of program committee of first and second "Workshop on Automated Theorem Proving with Analytic Tableaux and Related Methods".