Report on my visit to ICOT 10 February - 12 March 1992

François Bry
ECRC
(European Computer-Industry Research Centre)
Arabellastrasse 17
W - 8000 Muenchen 81
Germany
bry@ecrc.de

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1 Introduction

I arrived in Tokyo on February 10, 1992 for spending one month with the 5th laboratory of ICOT, headed by Dr. Hasegawa-san, on the kind invitation of Dr. Fuchi-san, director of ICOT. My departure from Japan and my return to Europe were scheduled for March 12, 1992.

Since the 5th laboratory is investigating the model generation paradigm to theorem proving, which, in its sequential form, has been first proposed at ECRC in a project I contributed to (the SATCHMO project), I have had close working contacts with many researchers of ICOT. Thanks to the kind visits to ECRC of colleagues from ICOT, in particular of Furukawa-san, Hasegawa-san, and Fujita-san on several occasions, I could follow the progress of the research on ICOT's parallel theorem prover MGTP (Model Generation Theorem Prover). More recently, during the Fall of 1991, I could meet again with several colleagues of ICOT during the "First German-Japanese Workshop on Deduction", held at GMD in Bonn, Germany. This workshop was for me an

additional opportunity to keep informed about the on-going research on the MGTP: it is worth mentioning that about a fourth of the presentations were devoted to model generation theorem proving or related issues.

The invitation to spend one month with ICOT was a unique chance to deepen my knowledge of the research on the MGTP, and more generally of the work pursued in this centre. Moreover, it was an interesting opportunity to learn more about Japan and its culture. In all respects, the four weeks I spent in Tokyo working at ICOT have not deceived my expectations.

In the following pages, I first briefly report about the issues I investigated during my stay with ICOT. Then, I outline the directions along which I plan to further pursue the work started during my visit to Japan. A following section is devoted to the meetings and technical discussions I have had at ICOT with several Japanese, American, and European colleagues or personalities of the research community. The technical presentations I gave are then listed. In a last section, I give my impressions about ICOT and the Fifth Generation Computer Project.

2 Issues investigated during my stay with ICOT

Although my research interests currently focus on deductive databases, the research pursued at ICOT on the parallel theorem prover MGTP is highly relevant to my own work. The reason is that model generation theorem proving, the paradigm on which the MGTP is based, relies upon hyper-resolution or bottom-up reasoning, like query answering in deductive databases. Moreover, the model generation approach to theorem proving has many aspects in common with databases. As a matter of fact, the model generation approach to theorem proving was inspired from databases techniques and concepts.

I am strongly convinced that model generation theorem proving can serve as a useful testing ground for database query answering. In my opinion, any strategy improving model generation theorem proving is potentially applicable to database query evaluation. Also, it is my conviction that optimizations primarily devised for deductive databases are likely to be relevant to theorem proving as well. Needless to say, the parallelization of model generation investigated within the MGTP project is also an issue of interest for database

query answering. The viewpoint that theorem proving and database research have more in common than it is usually assumed has been strongly sustained by the recent results obtained by Stickel-san, from SRI, during the visits he made in 1991 and 1992 to the 5th laboratory of ICOT.

In this recent work, Stickel-san extended the "upside-down meta-interpretation" technique to the model elimination theorem proving procedure. Upside-down meta-interpretation has been initially devised (at ECRC) for establishing the identity of reasoning principle shared by various database query answering procedures - such as OLDT Resolution (defined at ICOT in 1986), QSQ (defined at ECRC in 1987), the Alexander method (defined in the Bull research laboratories of Paris in 1985 and further refined at ICOT), and the Magic Sets procedure (defined at MCC in 1986). These procedures have been proposed during a sort of international scientific competition aiming at finding proof procedures better suited to database query answering than the formerly applied SLD Resolution procedure. In spite of considerable differences in the formalisms used in describing these procedures, it was possible to show that they in fact all implement the same reasoning principle, which was formalized as "upside-down meta-interpretation". In his recent work, Stickel-san has shown that the advantages of "upside-down meta-interpretation" over linear approaches such as SLD Resolution or traditional "linear" implementations of the model elimination proof procedure extend from database query answering to first-order logic theorem proving.

It was the intention of Hasegawa-san and myself that my visit to ICOT serves to investigate issues of common interest. Among the possible subjects we thought of while discussing my coming were the following issues:

- relevancy testing in model generation
- implementation of abductive reasoning in model generation provers
- further work on the parallelization of the model generation paradigm
- extending the MGTP with top-down reasoning with non-monotonic negation

The last topic was eventually retained, for the following reasons. Firstly, this issue can be seen as an extension of the research on relevancy testing in model generation provers, which is currently and successfully pursued in

the 5th laboratory. Secondly, it is reasonable to think that the "upside-down meta-interpretation" paradigm, which has been recently investigated with success in the 5th laboratory, could be applied for specifying and implementing a top-down reasoning procedure for non-monotonic negation. Finally, the selected issue is in itself a challenging and an important one: in spite of active research on the subject in the deductive database and logic programming community during the recent years, no fully satisfactory solution is yet known. A solution is however needed, in particular for an on-going database project at ECRC. Thus, the selected subject presented the advantages of being of interest for both ICOT and ECRC, and to be strongly related to current or recent results achieved in the 5th laboratory.

In order to specify a reasoning procedure for non-monotonic negation, it is necessary to first select a semantics for this form of negation to work with. There is currently no general agreement in the research community about which semantics should be retained. There are several proposals, that all have their attractive aspects, but also their drawbacks. A first task was therefore to rapidly review these proposals, and to select one of these semantics. The Stable Model semantics, proposed by Gelfond and Lifschitz had good chances to be selected for the following reasons. Firstly, it is already investigated at ICOT, and an elegant bottom-up proof procedure has been recently proposed by researchers of the fifth laboratory for implementing the Stable Model semantics with the MGTP (this procedure will be presented at CADE '92). Secondly, there is an abundant literature on this semantics from which ideas and partial results can be taken. Finally, the Stable Model semantics specifies total models instead of partial ones, in contrast to other semantics. Though likely to be more complex, a total model semantics is more convenient because it is somehow "more precise".

Unfortunately, the Stable Model semantics suffers from some deficiencies that make it hardly usable for top-down reasoning. I investigated these deficiencies and proposed the concepts of "composability" and "liar programs" for characterizing them. I also proposed a modification of the Stable Model semantics, so as to have a "composable" semantics at our disposal. Composability appears as a natural requirement for correctly handling updates as well as for defining a top-down reasoning procedure. A salient feature of this approach is that, the proposed semantics can cope with inconsistent data. Instead of being viewed as "undefined" or "unknown", certain literals are considered to be "overdefined", true and false at the same time, that is

inconsistent. Also, links between this semantics and the semantics of meta-interpretation have been investigated. More work is needed for formalizing these ideas. It is my intention to resume this research after my return to Europe. I believe that this "composable semantics", for the very reason of its composability, can lead to a "reasonable" top-down proof procedure.

The approach I studied during my visit to ICOT is, I think, promising. The very fact that it is close to other proposals - among others by Esghi and Kowalski, Kakas and Mancarella, Dung, and Przymusinski - speaks, in my opinion, in favor of it. Indeed, on a subject which has been so heavily studied by so many researchers during the last four or five years, a completely new approach would be highly suspect!

I am convinced that the technical discussions I have had here at ICOT with several researchers - among other with Fujita-san, Hasegawa-san, Inoue-san, Iwayama-san, and Satoh-san - will be of considerable help to me in further investigating the issue at ECRC. Also, I hope I shall keep in touch with the colleagues of ICOT, in spite of the distance between Tokyo and Munich!

Many people at ICOT are indeed knowledgeable on automated reasoning, logic programming, databases, abductive reasoning, etc. I have had many interesting discussions with several researchers, in particular with Fujita-san, Furukawa-san, Hasegawa-san, Inoue-san, Iwayama-san, Satoh-san, and Yokota-san - that were a considerable help in my own work. I am thankful to them for the time they spent explaining their results, speaking about their views and ideas, and patiently answering to the numerous questions I asked. Their very good knowledge of the field, the quality of their own results, and their great dedication to work significantly contributed to make the working atmosphere not only agreeable but also very stimulating. The work I could achieve during my visit owes a lot to the interaction with the colleagues of ICOT.

3 Directions for further research

As I already mentioned, the issue I started to investigate during the month I spent in the 5th laboratory of ICOT is of interest for both, this laboratory and ECRC. Moreover, the issue requires more work than what can reasonably be achieved within a few weeks. It is my intention to resume this research

upon my return to Europe.

First of all, the work achieved during my visit in Japan needs to be formalized and put down on the paper. Secondly, more work is needed for specifying and eventually implementing a top-down reasoning procedure for this "composable" semantics of non-monotonic negation. My intention is to investigate the upside-down meta-interpretation technique. If it would be possible to specify a top-down reasoning procedure in this formalism, its implementation in the MGTP as well as in a database context would be rather simple. Also, this would yield an interesting extension of the so-called Alexander/Magic Set rewriting technique to processing negation.

For certain reasons, I think that the formalization of meta-programming, another issue which is currently the subject of active research, is linked to the question of the semantics of non-monotonic negation. I therefore intend to further investigate this link. This issue is related to the activity of the 5th laboratory in two (loose) ways: on the one hand, the MGTP is implemented using meta-programming, on the other hand, upside-down meta-interpretation is also based on meta-programming.

Finally, non-monotonic reasoning is also linked with the question of updating data or knowledge bases. Better formalizations of updates are probably needed, if we wish to be once in position of processing updates in a more convenient manner than using the existing "ad hoc" techniques, such as "assert" and "retract" in Prolog. Investing updates could lead to further research on incremental reasoning. Such techniques would be, I think, useful for improving the MGTP. Indeed, real life problems often require to update the description of the applications. It would be very interesting not to have to re-compute all the previously performed deduction, in case a part only of the application knowledge is modified. Incorporating such incremental reasoning facilities in the MGTP would make it a more flexible, more efficient, and more convenient tool for practical applications. Again, I think that incremental deduction in the MGTP and in deductive databases are likely to have many aspects in common.

It is my hope that I shall keep in touch with the colleagues of ICOT, in particular with the colleagues of the 5th laboratory. As I already mentioned, their knowledge in our common field of research has been very valuable for my work during the month I spent with ICOT. Moreover, I think the research at ECRC on deductive databases could benefit from the results obtained with the MGTP, as well as of the ideal testing ground it is, for investigating

optimization techniques. Many of the above mentioned issues I consider to investigate in the forthcoming months might as well be of interest for the colleagues working on the MGTP. I think that further co-operation is likely to be beneficial for both parts.

4 Technical meetings, presentations, and discussions

I attended several demonstrations of systems and technical talks. A special mention must be made of the demonstrations of the parallel inference system developed at ICOT. I have been quite impressed by the quality of the presentations by Ishikawa-san on the use of the PIM system for genetic information processing, and by Ohtake-san on the use of the MGTP (implemented on a Multi-PSI machine) for legal reasoning. The applications demonstrated by these researchers cannot be seen as "real life applications", because, the aspects they cover are restricted. However, I think they can fairly be viewed as convincing "demonstrators" of potential, possible applications. The fact that much more routine work is still needed for implementing usable systems should not lead to oversee the non-routine, new contribution achieved so far and demonstrated by the above mentioned systems developed at ICOT.

The presentations by Furukawa-san and by Uchida-san on the achievements of the 5th Generation Project were as well very interesting for me. I have been especially interested in learning more about how ICOT was settled down, how it is managed, etc. It is my impression that, in many respects, the relationships between industry and research in Japan are comparable to what they are in the US and in Europe. Here and there, they are difficult, and this seems to be inevitable because of the objectives of both parts, that seem in many respects to be opposed, though they are in fact complementary. However, the essential role that the MITI is playing for promoting new research directions in Japan seems to be very specific to this country. I do not think that the US National Science Foundation, or the European ESPRIT program, or any other national or federal organization or program in the US or in Europe plays a role comparable to that of MITI in Japan. This essential difference between Japan on the one hand, and the US and Europe on the other hand, is, I think, a strength of Japan. In my opinion, Europe,

which currently is on its way towards unity, can learn a lot from it.

During my stay with ICOT, I also have had the chance of meeting with several colleagues and influential personalities from America and Europe. I have been kindly invited to join Stickel-san and Bledsoe-san for a two day visit to Kyoto on February 11 and 12. This was an opportunity for me to meet and speak for the first time with Bledsoe-san, Professor at the famous University of Texas at Austin, who is well-known for his work on automated theorem proving, and who has been vice-president of MCC. I had stimulating and interesting discussions with him. Also, the talk he gave at ASTEM on February 12 on his views of the major issues in automated theorem proving was very informative for me. The talk Stickel-san gave on the same day on his upside-down implementation of the model elimination proof procedure was also very interesting. I also met with Sakama-san and Christian-san, both from ASTEM, who also gave presentations about their current research. It was pleased to meet again with Sakama-san, who I had met in December 1989 during the first venue of the DOOD conference at ASTEM.

The first week of my stay with ICOT was also the last week of Stickel-san's visit to ICOT. I could have several technical discussions with him that were very informative and helpful to me. (He also introduced me to the fascinating city of Tokyo. His interest for the Japanese culture were the occasion of "technical" discussions of another type!)

On two occasions, I could meet again with Seki-san, from the Central Research Laboratory of Mitsubishi. I have had during the last years exchanges of correspondence with him. We also had met on a few occasions at international conferences. The two technical discussions I had with him have been stimulating and useful for me. I hope we shall remain in touch.

I also met with Richard Ling, from the University of Western Ontario, who was visiting the 5th laboratory. He introduced me through an interesting talk he gave at ICOT to the field of "inductive logic programming". I really enjoyed the opportunity of learning about a field of research which, up till that time, was rather unknown to me. I could see the relevance of Ling's work for automatic learning and for the research pursued at ICOT.

Laurent Kott, deputy director of the French Computer Science Research Centre INRIA, also visited ICOT during my stay in Tokyo. I enjoyed meeting with him, attending his presentation of INRIA, and also hearing recent news about France, my own country, which I have not visited since several months.

During the month I spent at ICOT, I attended two meetings of ICOT

working groups. This was an opportunity for me to see by myself that ICOT also plays an important role in the Japanese research community by bringing together researchers from Japan and from abroad. It is worth noting, I think, that these meetings organized at ICOT are attended by several researchers from both the industry and universities. Also, it is interesting to note that the researchers working in industrial laboratories who attend the ICOT working meeting were not all formerly involved in ICOT research projects. During the two meetings I attended, I could hear interesting talks. The talk by Robinson-san, the inventor of the resolution principle who was visiting the University of Tokyo, was especially interesting. I had moreover the chance of having a few technical discussions with him.

Finally, I would like to mention the very pleasant day I spent in Kyoto with Bledsoe-san, Stickel-san, Christian-san, and Fujita-san visiting some temples and enjoying the wonderful parks. This day, which was the first of my stay in Japan, has been an agreeable introduction to the country I only visited once before for a short time.

5 Presentations given

Visiting researchers are always expected to give talks about their recent - or less recent - work. I did my best for fulfilling the expectations of the colleagues of ICOT. On their request, I gave the following presentations. (The last one of the list below was suggested by myself, with the aim of reporting about the work done during the month spent with ICOT.)

12 February: - Deduction Methods for Databases - Database Approaches to Deduction
ASTEM RI, Kyoto

14 February: - Deduction Methods for Databases - Database Approaches to Deduction
ICOT Working Meeting on Automated Theorem Proving

27 February: - Public Transport Time Tables Viewed as deductive Databases - Integrity Constraints: Concepts and Methods
ICOT Working Meeting on Databases

6 March: - Non-monotonic Negation: Towards a Composable Semantics
for Logic Programs and Deductive Databases
ICOT - 5th laboratory

6 Some impressions about ICOT and the Fifth Generation Computer Project

During my stay with ICOT, I enjoyed its very good working atmosphere as well as the stimulating context it provides for research. The skills and the dedication to work of its researchers greatly contributed to make my visit fruitful and agreeable. The kindness and efficiency of its administrative staff must be mentioned.

Two aspects of ICOT deserve, in my opinion, to be especially emphasized. Firstly, ICOT does a remarkable training of young researchers. Secondly, its scientific management is very convincing.

Since a large part of the world research in computer science is done at universities, or at laboratories closely linked with universities, it is often considered natural that good research laboratories train well their young researchers. In my opinion, this is by far not so natural for industrial research centers. Moreover, this is not the case in many such laboratories. I think, a good training of young researchers is in fact rather difficult to achieve outside the university context. I therefore consider that the remarkable manner in which ICOT is training its young researchers is worth being especially mentioned. The average quality of the research achieved at ICOT is rather high. In some cases, the quality of the research is even very high. This would be for any research center a noticeable achievement. But at ICOT, this has not been achieved like in so many places by looking for "star researchers" on the "world employment market", but by training its own researchers. This approach is undoubtedly a difficult one, but surely the more meaningful for the country, and for the industry.

Secondly, I have been very impressed by ICOT's scientific management. The permanence of its technical targets since the beginning of the project and how these targets have been reached is, in my opinion, exceptional and remarkable. Defining good research targets is probably one of the most difficult tasks in research. Defining good targets for a period of time of ten

years, for several tens of researchers is, in my opinion, especially difficult. This has been done at ICOT, and, I think, very well done. The fact that, as far as I know, only a few adjustments of the initial research objectives have been needed in the course of the project is noticeable. Clearly, the scientific preparation of the project must have been very good. The people scientifically managing it are clearly very skilled.

It is therefore my hope that something will remain of ICOT after 1993. It is surely desirable to start new research projects. It would be wrong to pretend stop the time. However, ICOT seems to me to be so successful and efficient, that it is my hope that something of it will remain. This is surely the interest of the research community - and, I think, also of Japan.

I would like to conclude this report with a special mention of the many kind attentions people had for me during my stay. The administrative staff of ICOT has been very helpful and efficient. Furukawa-san, Hasegawa-san, and Iwata-san as well as many administrative employees, and all the researchers I worked with helped me in many ways for making my visit to ICOT fruitful and agreeable. I would like to thank them very warmly. I would like to make a special mention of the two excursions that Iwata-san organized for me and other visitors. They greatly contributed to make my stay in Japan agreeable.

Résumé

François Bry

August 1991

Civil Status:

born 10 August 1956 in Paris
French citizen
married, two children (10 and 4 years old)

address: Jakob-Klar-Str. 3, W 8000 Munich 40, Germany
tel.: 49 89/92 69 91 48 (office), 49 89/92 69 90 (secretary),
49 89/271 72 44 (home)

Primary and High School Education:

1962-1964: Primary school in Rabat, Maroc
1964-1966: Primary school in Nancy, France
1966-1968: Primary school in Paris
1968-1971: High school in Ivry, suburb of Paris
Grant of the French Education Ministry
1971-1974: Private high school *Ecole Alsacienne* in Paris
Grant of the *Ecole Alsacienne* and grant of the French Education Ministry
1974: School leaving certificate, speciality "sciences"
(French *baccalauréat série C*)

University Education:

1974-1976: Applied Mathematics at Paris University
1976: Degree: DEUG in Applied Mathematics
(First degree at French Universities)
1976-1978: Mathematics at Paris University
1977: Degree: *Licence de Mathématiques*

1978: Master degree in Mathematics
(Maîtrise de Mathématiques)
1978-1980: Ph.D. student with supervisor C. Berge at Paris University
Grant of the French Research Ministry
1979: Degree: *Diplôme d'Etudes Approfondies de Mathématiques*
1981: Ph.D. in Mathematics
(Doctorat de 3ème cycle en Mathématiques)

Military Service:

Feb. 1982 - Jan. 1983:
Officer training, then public relations officer in the French Air Forces

Employment:

Sept. 1979 - July 1981:
Researcher (PhD student) in the Research Group "Combinatorics", Paris University and CNRS
Aug. 1981 - Jan. 1982:
Software engineer at TRANSAC, Paris-Massy
Feb. 1982 - Jan. 1983: Military service
Feb. 1983 - Dec. 1984:
Researcher in the Applied Mathematics and Computer Science Department of *IRT*, Paris-Arcueil
(Research centre of the French Transportation Ministry)
Jan. 1985 - Dec. 1989:
Researcher in the Knowledge Bases Group of the European Computer-Industry Research Centre (ECRC, Arabellastr. 17, W 8000 Munich 81, Germany)
Jan. 1990 - present:
Team leader for Basic Research in the Knowledge Bases Group at ECRC

Languages:

English, French, and German.

Professional Societies:

AFCET (French Applied Mathematics and Computer Science Society)
ALP (Association for Logic Programming)
GI (German Computer Science Society)