

Report on a Visit to ICOT

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1 Introduction

I was invited to ICOT by Yokota-san for the period December 11, 1989 to December 15, 1989. The invitation came as a result of my attendance at the DOOD89 Conference in Kyoto, where I was Chairman of the Steering Committee.

I have had many contacts with researchers from ICOT over the past years. Recently, Mr. Ken Sato visited my laboratory at the University of Maryland and Dr. Mukai attended my workshop on "Foundations of Deductive Databases and Logic Programming," held in 1986. Dr. Mukai was one of the lecturers at the workshop.

I was particularly interested in visiting ICOT to discuss my work on deductive databases, logic programming, parallel logic programming and non-monotonic reasoning with researchers at ICOT and to learn what they are doing in these areas. Much of my research relates to work being done at ICOT.

My visit consisted in participation in a two day workshop on deductive databases organized by Yokota-san on Monday and Tuesday, a visit with

researchers in the different laboratories and several lectures on: "Disjunctive Logic Programming," and "Parallel Logic Programming in PRISM."

I will briefly describe my observations and conclusions based upon my visit. It should be understood, however, that observations based on a very short visit should not be considered as conclusive.

2 Workshop on Deductive Databases

The Workshop consisted of two parts: informal panel discussions and formal and informal lectures. I will summarize my observations of the panel discussions and of the informal papers.

2.1 Panel Discussions

There were two basic panel discussions: (1) What is the Future of Deductive Object-Oriented Databases and Deductive Databases?; and (2) What is the Next Generation Database System?

With respect to the first panel discussion, there were no firm conclusions reached. Different researchers had diverse opinions. The major focus was on deductive databases. There were a number of researchers, primarily from Japan, who did not believe that deductive databases were viable. Their argument was that relational databases were less efficient than other types of models, for example, the network model. Other participants both from outside of Japan and from Japan did not believe that this was an accurate representation and they could not believe that users wanted procedural rather than declarative languages with which to query databases.

The importance of query optimization was stressed for deductive databases. It was also stressed that if deductive databases are to be viable, then it will be essential to make a working system available for use by a wide diversity of individuals. Such a system should have a reasonable number of functionalities, but need not solve all of the problems being addressed in the field of deductive databases.

The second panel led to presentations that were very long-range and would require a great deal of research to determine if they were viable. Discussion was held on the next generation deductive system which would contain an object-oriented deductive component and would borrow techniques

from the field of artificial intelligence. The next generation object-oriented system would consist of active objects that contain procedures with the object. It was unclear as to what the semantics of either of the two approaches would be. No general conclusions were made concerning future new generation database systems.

2.2 Formal and Informal Presentations

A number of presentations were made by:

Minker - "Disjunctive Logic Programming,"

Tanaka - "Vocabulary Based LP,"

Bry - "Intensional Updates,"

Vieille - "Deductive Databases at ECRC"

Abiteboul - "Object Oriented Languages," and "Object-Oriented Systems at INRIA,"

Bancilhon - "Object-Oriented Programming at Altair,"

Yokota - "Deductive and Object-Oriented Databases at ICOT."

The research reported by Tanaka and Minker was not related directly to current implementations of deductive databases. Tanaka spoke about his method of incorporating vocabulary into logic programming. Minker spoke about the semantics of disjunctive logic programming. He developed fixpoint, model theoretic and proof theory semantics and surveyed the results that are known in the fields of Horn and Disjunctive theories.

Bry discussed his theoretical work on handling intensional updates in deductive databases. Updates will have to be part of any realistic deductive database. Vieille described the work at ECRC to achieve a deductive database. It was observed that their system is very close to being a product that could be used by others and they were encouraged to make available a prototype of their system for use by others.

Abiteboul discussed theoretical work that he has done with Kanellakis to provide a framework of a theory for object-oriented databases. He also described work being done at INRIA. Bancilhon described the object-oriented system that he is developing. The system has gone through several prototypes and is expected to be available in 1990 or 1991. The work is important and bears following to determine how successful it will be. Bancilhon also estimated that there is a significant market for object-oriented systems. Yokota-san discussed the research he is doing on object-oriented and deduc-

tive databases with the Kappa system. The work is significant as it attempts to incorporate a deductive mechanism in the context of an object-oriented system.

The Workshop was successful. It will be important to have workshops in the future that will bring together practitioners in the field of deductive and object-oriented systems. Yokota-san should be congratulated in having developed such a successful workshop and for attracting many important researchers to participate in the workshop.

My personal view is that the fields of deductive databases and object-oriented databases will be merged in the near future. What must happen is that a purely object-oriented database system must be implemented and shown to be useful. This is also true of a purely deductive system. Once this is accomplished, it will be possible to develop a system that combines the two efforts and yields a semantics for the system that is clear. The work of Yokota-san in combining object-oriented systems and deduction, and the theoretical work of Abiteboul, Beeri and Kanellakis in developing a clean semantics for object-oriented systems, will be important. The work at ECRC appears to be the deductive database system most likely to become usable outside of the laboratory. If deductive and object-oriented databases are to be used for large knowledge engineering systems, it will be necessary to incorporate semantics, captured by integrity constraints, in the search process.

3 Research in the Fifth Laboratory

Discussions were held with the following members of the Fifth Laboratory whose work is in the area of knowledge base systems: Kawagashi, Yokoyama, and Inoue.

Kawagashi described work that he is doing to find the supremum and infimum of convex sets described by linear inequalities. He has implemented an algorithm on the PSI sequential machine. He has not yet implemented the work on multi-PSI since it does not yet have floating point arithmetic. He has developed two basic algorithms. The first leads to redundant paths. The time to execute the program was not specified, but let it be k . By saving answers, as done with the Fibonacci program, he is able to obtain a 10-fold improvement in his program. A parallelized version of his first algorithm on $2n$ machines is anticipated to result in an improvement of $k/2n$, and for

the second parallel system of $k/20n$. The last result remains to be seen. The work shows the importance of effective algorithms since the improved sequential algorithm will yield better results than a machine with 5 parallel processors.

Yokoyama is working on object-oriented systems with constraints. The system is implemented on PSI. He is investigating heuristics to determine how best to handle constraints. It is unclear how to find the required heuristics, as even experts have difficulty in this area.

Inoue is working in the area of disjunctive theories and circumscription. He is interested in computing over these theories. The work is being done with two visitors and appears to be quite interesting. It relates to work that I have done and Inoue requested that I send him some of my reports.

The work in the fifth laboratory seemed to be of interest. It was unclear from the short amount of time as to the focus of the research in the group and who was directing the research.

4 Research in the Fourth Laboratory

Discussions were held with Chikayama and Uchida. Uchida-san described the developments that have been made in hardware at ICOT and the current hardware implementations at manufacturers such as Fujitsu and Mitsubishi. The PIM/ systems were outlined. The current efforts at ICOT appear to be at the programming level. The introduction of the metacall and priority features by Chikayama-san are useful concepts. To evaluate the parallel processor, four programs are being tested. These are: Pentomino (a problem related to packing pieces in a rectangular area), PAX (a natural language parser), GO (the game of GO), and Best Path Finding. I briefly described the work at Maryland on parallel logic programming and Chikayama-san suggested that I present a lecture on Friday morning. It would be of interest to obtain the code for the four problems so that I may test them on the PRISM system developed at the University of Maryland with my students and to compare results obtained on programs at Maryland with results obtained at ICOT on multi-PSI.

The work on multi-PSI is of considerable interest. I inquired about the possibility of using multi-PSI over the net. Arrangements are being made with Argonne National Laboratory to permit them to interconnect with

multi-PSI, and it may be possible to tie-in with that effort.

5 Research in the Second Laboratory

Discussions were held with Hashida, Tsuda, Mukai, and Yasukawa. Hashida-san discussed a natural language parsing system. The natural language part was conventional, based upon definite clause grammars. Of interest was the question-answering part based on the parsed sentence. When a question cannot be asked precisely, the system generates presuppositions. Based upon the presuppositions an answer may be found. There was insufficient time to explore the details of how this was accomplished. If it is done in a general way, then the approach is of considerable interest. Tsuda-san discussed his work on adding constraints to logic programs. The work is also of considerable interest. Mukai and Yasukawa discussed Mukai's general theory of a tree algebra. The work is of interest. It is unclear how effective the approach will be for knowledge base systems since there is no concept of negation or quantification in the theory.

6 Research in the First Laboratory

Discussions were held with Aiba, Sato, Poole and Helft. Aiba-san has investigated the problem of adding nonlinear constraints and solving them in constraint logic programming. The work seems to be very good and of particular interest. I discussed with Sato-san his work and the possibility that it may be related to work in natural language generation. Poole and Helft discussed their research in extracting answers in circumscription. The work relates to disjunctive logic programming with general clauses in which there are negated atoms in the body of a clause that contains disjuncts in the head of the clause. It will be of interest to determine if the generalized disjunctive well-founded semantics, developed by Baral, Lobo and Minker, will compute and extract answers to their queries. They have developed an algorithm to answer queries. They have shown that work by Przymusinski and Ginsburg is not appropriate in their context. It will be of considerable interest to receive their paper and to determine the relevance of the generalized disjunctive well-founded theory to their work. The collaborative work of Helft,

Poole and Inoue has been very productive in the short period of three weeks.

7 Conclusion

There is a great deal of research being conducted at ICOT that is of interest to my work. I regret that I was unable to visit ICOT at an earlier date so that we could have arranged for more exchanges of research ideas. ICOT has made significant strides in the nearly 8 years of their existence. The development of a parallel logic hardware system, multi-PSI will be useful to determine parallel hardware products that should be developed. The work on object-oriented deductive oriented systems will be important for future work in developing database products.

It is not surprising that all of the objectives set out at the initiation of the ICOT effort have not been met. In any ambitious research adventure, it is unrealistic to assume that all of the objectives will be met. What has been accomplished at ICOT is significant. A large cadre of researchers have been trained in the area of artificial intelligence and in computing; the first prototype parallel logic programming hardware has been constructed; tools and techniques have been developed for parallel and sequential systems; deductive database systems and object-oriented database prototype systems are being developed; knowledge engineering tools are also under development. From my brief observation the researchers at ICOT are very capable and they are performing very fine research. MITI can be proud of the accomplishments made by ICOT.

The termination of the ICOT project in two years is a problem that needs to be addressed. Many interesting ideas have been spawned by the project. With the effort being disbanded, it is not clear how the experience will be transferred that has been gained by the many researchers at ICOT. Without proper planning there is a danger that the researchers will be dispersed at the end of two years and the accomplishments of ICOT may be lost.

8 Acknowledgements

I would like to express my appreciation to the management and directors of ICOT who so graciously supported my visit and who welcomed me warmly.

Mr. Itawa was kind to greet me, to provide orientation about ICOT, and to help me change my reservations back to the United States. Mr. Hiroichi Hiroshige, Executive Director, was kind to greet me and to invite me to a lunch with the management of ICOT. Dr. Kazuhiro Fuchi, Director of the Research Center and Dr. Furukawa were kind to make available their researchers to meet with me and to brief me on their research. They have created a fruitful environment for their researchers and for visitors from foreign countries to openly exchange research ideas. Dr. Uchida, Director of the 2nd and 4th laboratories greeted me warmly, briefed me on technical matters and joined me for special banquets. I am especially indebted to Kazumasa Yokota for inviting me to ICOT, for making hotel arrangements for me and for assisting in me in many ways that are too numerous to mention. The warm reception I have received at ICOT made me forget that I was in a foreign country. I felt like I was among friends and colleagues while visiting at ICOT. Everyone was interested both in my research and in explaining their research to me.

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PERSONAL DATA

July 4, 1927
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EDUCATION

BA (cum laude with honors in Mathematics - major, Education - minor), Brooklyn College, New York	1949
MS Mathematics - University of Wisconsin	1950
PhD Mathematics - University of Pennsylvania	1959

EXPERIENCE IN HIGHER EDUCATION

University of Wisconsin, Graduate Teaching Assistant	1949-1950
National Institute of Health, Graduate School	1965-1966
University of Maryland, Visiting Member	1967-1968
University of Maryland, Associate Professor	1968-1971
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University of Maryland, Chairman, Department of Computer Science	1974-1979