Report on my stay at ICOT

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In April I was visited in Dortmund by Dr. Ryuzo Hasegawa and Hiroshi Fujita from ICOT. We had an intensive and interesting discussion about theorem proving techniques in which several common points of interest became apparent, in particular concerning the relations between different proof calculi and ways of safe pruning of search trees. A few weeks later I recieved an invitation from Dr. Kazuhiro Fuchi to visit ICOT as a visiting researcher.

I visited ICOT from 18th July to 17th September 1990. I was introduced to the activities of the seven research laboratories at ICOT by a number of talks and demonstrations of running software and hardware systems. I was impressed by the range of fields in which excellent research is being done at ICOT. It covers the topics of hardware systems for parallel inference machines (PSI, Multi-PSI, PIM), operating systems (PIMOS) for these machines, knowledge base and data base management systems and knowledge representation models and languages (Kappa-II, Juan, Quint, Quixote), constraint logic programming (CAL), automated theorem proving, natural language interface (DUALS), and application software for parallel inference machines and parallel programming techniques and parallel AI techniques. One of the main issues in parallel computing that is being extensively studied in ICOT is the problem of load balance. In automated theorem proving,

several approaches have been and still are being implemented at ICOT. Thus a comparison of the different methods and calculi is being made sorting out their respective strengths and weaknesses. This is a subject that is particularly interesting for me. Many aspects of this issue have frequently appeared in our discussions at ICOT.

I am convinced that all these areas which will enter into any advanced information processing system of the future. And I am sure that the results achieved here at ICOT will play a major role in these systems. I fully agree with the approach taken by ICOT to place logic, automated theorem proving, and logic programming at the bases of developing advanced computer technology. Logic as a language is powerful enough to describe any system or theory which can be formalized. On the other hand, for purposes of efficiency it can easily be restricted so as to allow easy computations, as the success of Prolog and other Horn clause based systems has shown.

I gave four talks at ICOT. The first talk was entitled "The Connection Method". In it I gave an introduction to the connection method and some of its refinements as well as a brief sketch of the normal form transformation of a formula to its definitional form. The second talk, "Theorem Proving Based on Paths and Connections", addressed two major issues. First, it gave a comparison between the connection method and resolution, concentrating on the question of simulation of one calculus by the other. Second, the path set calculus and the connection structure calculus were introduced. Each of these two calculi constitutes a synthesis of the connection method and resolution and allows to simulate them step by step. The third talk, "Connection Structures" was given to a different audience than the second. It had a similar theme, but I could build upon a well founded knowledge of the connection method in the audience, and so I could concentrate the talk more on the issues concerning the path set calculus and the connection structure calculus. The fourth talk, "The Extension Rule in First Order Logic", dealt with the generalization of some of Tseitin's results from propositional logic to first order logic. The main points of this talk were to show how proofs of an arbitrary first order formula in the cut-free sequent calculus can be simulated by resolution after having transformed the formula to its definitional form. For proofs in the sequent calculus with cut, a generalization of Tseitin's extension rule to first order logic is needed in addition to the resolution rule.

At ICOT I had various fruitful and interesting discussions and talks with many of my colleagues here at ICOT, on theorem proving, logic and com-

puter science, but also about topics not related to our research. I want to specially mention Dr. Koichi Furukawa, Dr. Ryuzo Hasegawa, Masayuki Fujita, Hiroshi Fujita, Miyuki Koshimura, Hideji Kawata, Tadashi Kawamura and Ken Satoh. During the last days of my stay here, Mark Stickel arrived at ICOT for a three month visit, and I profited much from discussions with him.

Our discussions mainly centered on three issues. One subject of discussion were the relations between proof calculi, in particular the connection method, model elimination, model generation, tableaux, resolution, path set calculus and connection structure calculus. We agreed that model generation is a restriction of model elimination which in turn can be viewed as the simplest version of connection calculi. We also had discussions on the problem of safely pruning the search tree in the search for non-complementary paths. Elimination of a subtree in tableaux-like calculi in the presence of a different occurrence of the same subtree in the tableau is identical to the concept of factorization in the connection method. We had discussions about the implementation of the connection structure claculus that is going to be done by scientists at ICOT. One point that we discussed in this respect is the generation and use of lemmata. We discussed two strategies for generation of lemmata. The forward strategy tries to derive from the input clauses some clause or path set that looks interesting and remembers it as a lemma. Preference is given to unit clauses. The backward strategy analyzes the current subgoals and if it finds two subgoals that are of similar syntactical structure then it tries to prove a goal which has both of these subgoals as instances. These points are particularly important for the third major subject of our discussions, the implementation of the connection structure calculus that is going to be done at ICOT. There seemed to be general agreement about the proposal to use the strategy of the connection method as a default and deviating from it only in cases where the use of lemmata looks promising. This will be the case in particular when there is a cycle in the set of connections which is being traversed several times, as well as in the case of two subgoals of similar structure.

I have done some research at ICOT which yielded two results, the establishment of the path set calculus on which I started writing a paper at ICOT, and a transformation transforming a proof of a definitional form of a given formula in the resolution calculus to a proof of this formula in the sequent calculus. It seems that also a transformation of a resolution proof of

a formula that is already in normal form to a proof of the same formula in the sequent calculus can be easily obtained. This will be a theme of future research.

I also visited Kyoto University and met there with Dr. Matsumoto and Dr. Hagiya. I gave a talk there on "Path Oriented Proof Methods".

I am very grateful for the generous hospitality I enjoyed so much here in ICOT the many times I was treated to lunch or dinner or invited to parties. Besides experiencing some of the summits of computer science at ICOT I was also led to the geographical summit of Japan by Masayuki Fujita with whome I enjoyed a very nice hiking tour up to Fujisan and a beautiful sunrise at its crater rim. In Kyoto, Tadashi Kawamura showed me parts of Kyoto University and introduced me to scientists there, and he showed me some of the most interesting sightseeing places in Kyoto and Nara. Akira Aiba told me many interesting things about Japanese culture and religion, and he showed me also some of the secret cultural treasures of Kamakura. For me Tokyo was a huge city in which I had great difficulties to find my way until the day when Susumu Taba lent me his bicycle. I would never have seen so many interesting things and attended so many interesing festivals in Tokyo if I did not have a bicycle during my stay here. I want to thank him also for his patience when the police called him at his home to ask him whether he has lent me his bicycle. Dr. Iwata made the administration work for me and arranged an appartment for me in what I think is one of the nicest parts of Tokyo.

In view of the high quality of work being done here at ICOT and of the results that have obtained from this research and from the great impact it has had so far on advanced computer science and Artificial Intelligence in general, I hope very much that after the end of the final stage of this project the efforts being made in this area here in Japan will be continued in some sort of follow-up project.

Curriculum Vitae

Personal data

Name:	Elmar Eder
Birth:	6 May 1956 in Vienna
Address:	Baroper Str. 354, D-4600 Dortmund 50, West Germany
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Nationality:	Austrian

Education

Primary school:	Autumn 1962 – summer 1965 in Munich and Garching, West Germany.	
Secondary school:	Autumn 1965 – summer 1970 at the Maximilians-Gymnasium in Munich (classical secondary school). Autumn 1970 – summer 1971 at the Millfield School in Street, England (public school).	
Graduation:	Summer 1971 General Certificate of Education, University of Oxford, England.	
University:	Autumn 1968 – end of 1977 at the Ludwig-Maximilians-Universität (LMU) in Munich in mathematics, physics and mathematical logic. 1/1/74–12/31/77 Scholarship of the Studienstiftung des Deutschen Volkes. Autumn 1977 – summer 1979 at the Technische Universität München in computer science.	
Graduation:	Vordiplom:	August 1970 at the LMU with mark "very good".
	Diplom:	September 1974 at the LMU with "very good".
	Doctorate:	October 1977 at the LMU with "very good".
Fields:	Dipl. Thesis:	Partial differential equations.
	Dissertation:	Mathematical logic, constructive theory of ordinals, recursion theory.