

# Report on a Visit to ICOT

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### 1 Introduction

I was invited to come to ICOT when Dr. Iwata visited GMD in the spring of this year. I immediately decided to accept this kind invitation since ICOT is one of the world's most famous research institutes and the high quality of the research performed there is known throughout the world. Moreover, my colleague Franco di Primio, who spent four weeks at ICOT in 1987, has always told us how interesting and fruitful his stay at ICOT was.

In 1988 some ICOT researchers, Jun Arima and Ken Satoh, met me in Germany. This was my first personal contact with ICOT, and we spent an interesting day at GMD and in Bonn together. Another ICOT researcher, Katsumi Inoue, came to GMD while I was absent. He discussed with my colleague Ulrich Junker. From both of these visits we were aware that ICOT and GMD have very close research interests in the area of nonmonotonic reasoning. Research papers were exchanged regularly, and this, of course, even increased my interest to come here.

My impression was that the importance of the area of nonmonotonic reasoning for Artificial Intelligence is clearly recognized at ICOT (may be even clearer than at GMD or in Germany in general). I consider the problems addressed in this area, namely the representation of defeasible commonsense knowledge, as essential for the success of AI. More and more people seem

to share this view. A look at the proceedings of this year's conference on Principles of Knowledge Representation and Reasoning (KR 89), Toronto, for instance, shows that more than half of all accepted papers directly deal with nonmonotonic reasoning, many of the remaining papers address issues related to nonmonotonic reasoning. (By the way, it is certainly not incidental that an ICOT researcher was among the speakers of this conference).

Before describing in more detail the content of our numerous discussions and presentations I had the opportunity to participate in as a guest of ICOT's first lab let me just very briefly describe my feelings as a foreigner who came to Japan the first time in his life. Thanks to the hospitality of many people in ICOT I felt like home from the first day I arrived at ICOT. Dr. Iwata perfectly organized my accommodation in Tokyo, and his idea to stay at a hotel close to ICOT the first days and then move to an apartment should be recommended to every visiting researcher. Ken Satoh, Katsumi Inoue, Nicolas Helft and in particular Jun Arima did a great job showing me how to survive in ICOT and in Tokyo. They explained many aspects of Japanese life to me and showed me interesting places a foreigner would never find without help.

My impression is that ICOT's research exchange program is an excellent idea and probably the best way to cooperate with researchers from other countries. Of course, a period of about three weeks is not enough to do something new. But it is enough to clarify positions and to go home full with new ideas and plans, and hopefully, to leave some ideas in the heads of some ICOT researchers, too. I would be very glad if GMD would establish a similar exchange program.

## 2 Presentation of ICOT's research activities

When I arrived at ICOT Jun Arima had already worked out a program for the first two weeks of my stay filled with discussions and presentations. The first presentation was Nicolas Helft's and Katsumi Inoue's approach to proof procedures for nonmonotonic systems. This approach, which is based on Pierre Siegel's work on preferred models, generalizes former approaches in a way which makes it very easy to understand the differences (and difficulties) of many existing algorithms. This is a very important contribution to the field, since it helps to avoid a further proliferation of approaches to the same problem. It is still not absolutely clear, how general the proposed method is. One important condition for its applicability is certainly cumulativity of

the inference relation of the logic at hand. Cumulativity means, intuitively, that the addition of a theorem to the premises does not change the derivable formulas. If this property does not hold, as it is the case with Reiter's default logic, the proposed method does not work. The interesting open question is whether for all cumulative logics the method is applicable. Nicolas Helft will try to establish a formal result. In any case for many known nonmonotonic logics the approach is promising and we at GMD will try to find out whether it can be used for our future projects.

In the next presentation Katsumi Inoue presented his generalization of de Kleer's ATMS. In this model based approach an ATMS is seen as a propositional hypothetical theory consisting of axioms and hypotheses. Any propositional formula is allowed in both sets. Many notions known from the basic ATMS can be generalized in a natural and elegant way with this approach: environment, minimal support, extension etc.. Moreover, Inoue introduces the notion of model-based ATMS, which provides an interesting alternative way of maintaining contexts. Nonmonotonic justifications are also introduced in a way related to Dressler's approach. The hard problem of how to incorporate the notion of groundedness into this approach is not solved yet. It might be, however, that for many practical applications this problem will simply not arise. What impressed me was that the theoretical work on ATMS rests on a solid implementation experience, certainly a fruitful basis for future work in this interesting field.

Jun Arima then presented his work on circumscription. He has detected some deficiencies in the original versions of this formalization of common-sense reasoning which originally has been proposed by John McCarthy. Circumscription allows to minimize the extension of some predicates. Instead of defining the entailed formulas to be those true in all models of a set of premises only some of the models - the preferred ones - are considered. Since the preference relation on models makes only models with the same domain comparable a minimization of the equality predicate is impossible. Arima provides a nice example which clearly shows the counterintuitive consequences of this problem. Moreover, closely related to the mentioned limitation is the difficulty of formalizing the unique names assumption with circumscription.

Arima's solution to the problem, intuitively, minimizes the set of names denoting abnormal objects instead of the objects themselves. This, however, turns out to be very difficult: an additional universe is needed with complicated mappings between symbols and elements of the new domain. Even a formalization of number theory is used. It was interesting to hear that John

McCarthy, when confronted with the paper, said that he cannot understand such complicated things. He promised to give the paper to Vladimir Lifschitz. I'm very interested to hear about his reactions to the problem and Arima's solution.

The next presentation was given by Ken Satoh. He uses a specific ordering on the models to express the notion of relative plausibility. The goal is the ability to express sentences like "disease 1 is more plausible than disease 2", or "if a certain symptom is found, it is plausible that the disease is disease 1". Meta statements are used to express that one formula is more plausible than another one. If a set of such meta statements is given (together with a set of premises), then an ordering of the models of the premises can be defined, such that the preferred models (according to this ordering) allow to derive results which correspond to the intended meaning of the meta statements. A number of interesting results about this notion of plausibility have been derived by Ken Satoh. Moreover, he has applied his ideas successfully to the formalization of inheritance systems and temporal projection.

Bernard Burg, fifth lab, presented his Ph.D. work on induction in mechanical engineering to me. Moreover, he showed me how to program the multi-PSI in KL-1 and explained some of the difficulties of parallel programming in general.

### 3 Presentation of my own work

It was a great pleasure for me to be able to present some of my own ideas to ICOT's expert audience. I first presented some ideas of how to avoid some problems arising in the framework of Reiter's default logic. In certain cases, the results obtained in this logic are too weak. The reason is that defaults are represented as inference rules in the logic, but no combinations of such defaults are possible. In particular in the presence of disjunctive knowledge some intuitive conclusions cannot be drawn. The introduction of the notion of "disjunctive closure" helps to solve the problem. Intuitively, if two defaults are given, then the disjunctive closure contains also a default which has as prerequisite and consequent the disjunction of the original defaults' prerequisites and consequents, respectively, and the conjunction of the justifications as justification.

The other problem is related to semi-normal defaults. Here we get in certain cases too strong results because nothing in Reiter's definition of default logic guarantees that all justifications of all defaults have to be con-

sistent with what has been derived. A solution to this problem proposed by Lukaszewicz, unfortunately, destroys the additional expressiveness of semi-normal defaults, namely the ability to express priorities between defaults. I presented a further modification of default logic which solves the problem without sacrificing expressiveness. This solution is based on weakening Lukaszewicz's applicability condition of defaults somewhat. I'm lucky that I was able to write a paper on these topics during my stay at ICOT. The paper is almost finished and will be submitted for publication as soon as I'm back in Germany.

The other part of my talk was based on Poole's logical framework for default reasoning. This approach has gained much attraction since it is very simple and elegant and yet quite expressive. There are some problems, however: the applicability of a default may be blocked given some exceptional condition, but it is not possible to express priorities between defaults adequately in this framework. I showed how to generalize Poole's ideas to achieve this additional expressiveness. The basic notion of this generalization is that of preferred maximal consistent subsets. If an adequate preference relation on such subtheories is chosen, then it is possible to introduce defaults with different degrees of "reliability". In the most general case, a partial ordering between the formulas representing their relative reliability can be defined. Our hope is that the proposed framework for default reasoning might be a good compromise between simplicity and expressiveness. Moreover, the problem of handling inconsistent knowledge is implicitly solved in this approach, a problem every intelligent agent has to be able to deal with anyway.

## 4 Other Events

Thanks to ICOT I was able to attend a symposium on AI evolution on Friday, 7th. Very prominent AI researchers were among the panelists: Shunichi Amari, Koichi Furukawa, John McCarthy, and Donald Michie. Moreover interviews with Marvin Minsky, John Searle, Noam Chomsky and many other important people in the field had been recorded and were presented during the panel discussions. Unfortunately, the discussions were quite general (can machines have consciousness?). I would have expected more controversial discussions about different approaches to AI, such as the logical approach or subsymbolic approaches. Interesting talks about the history of AI were given by McCarthy and Michie. The latter tried to show that Turing had foreseen

a lot of important developments in the field. What I missed, however, from the whole panel were ideas about the future evolution of AI.

It is a good indication for the high international reputation of ICOT that John McCarthy came on Saturday morning to present some very new ideas about a future programming language to researchers from ICOT. This new programming language, called Elephant 2000, is based on Searle's speech act theory. A program does not just follow instructions, it is able to perform speech acts. In particular, the notion of commitment is considered important. McCarthy gave a flight reservation example and showed how such a language might be used for similar problems. He claimed that nonmonotonic compilation techniques were necessary for such a language. These ideas are still in a very preliminary state. But it is certainly worth exploring them further.

The other scientific event outside of ICOT I was able to participate in was the Logic Programming Conference. Unfortunately, there were not many talks in English, but these (two) talks were very interesting for me. Donald Michie, in his opening talk, gave quite a broad overview on the area of concept learning, in particular he talked about an interesting new learning system developed at his Turing Institute. He emphasized the importance of nonmonotonic reasoning for learning, and the newest version of the system he described also includes nonmonotonic features.

Nicolas Helft presented in his talk a very interesting new approach to inductive reasoning which solves some of the problems of the classical approach. The set of generalizations of a knowledge base is nonmonotonically derived from the knowledge base itself. The fundamental assumption underlying induction, namely that objects whose behavior is unknown behave "similar" to the known objects, is captured by the notion of minimal models (all predicates are minimized). Additional injectivity conditions guarantee that no "unnatural" generalizations are obtained. Many people always have intuitively felt that the relation between learning and nonmonotonicity must be close. Here is a paper that makes this intuition precise. I think KR-89's referees did a good job when they accepted that paper and included it in what they regard as the 'very best work being done in the area of knowledge representation and reasoning' (preface to conference Proceedings).



## 5 Conclusions

Of course, I cannot mention all the various other, less formal discussions I had with various ICOT researchers during my stay. There were too many to mention just the topics. I will, therefore, restrict my description in this report to two further discussions which may serve as examples for the fruitfulness of my visit.

In one of the discussion Katsumi Inoue and I tried to clarify some problems related to consistency maintenance in justification based truth maintenance systems. Based on one of my earlier papers we went through several dependency directed backtracking algorithms and tried to understand their different behavior in some interesting cases.

The other discussion I'd like to mention was one I had with Nicolas Helft on an unpublished paper of Kurt Konolige. Based on that paper we tried to figure out how it might be possible to develop a reasoner such that the quality of conclusions the system is able to derive improves proportionally with the time it is given for solving the problem. It seems that a good starting point would be to consider very general defaults first which, in most cases, produce good results, and to consider possible exceptional cases only if enough time is available. It would certainly be fruitful to explore these ideas further.

The main new ideas that I got during my visit and topics I will try to explore further in the near future are certainly the implementation techniques for nonmonotonic reasoning developed at ICOT, and on the other hand the relation between learning and nonmonotonic reasoning. I think both of these fields could learn a lot from each other if there were a bit more scientific exchange in the still different research communities.

For me, these almost three weeks at ICOT were intellectually very exciting. But not just intellectually. I enjoyed very much Japanese culture and the Japanese style of living (as far as it was possible in this short period of time). This was my first visit to Japan, but I know for sure that it was not the last one.

I would like to thank, first of all, Dr. Fuchi for inviting me to ICOT and giving me the opportunity to experience the stimulating spirit of ICOT. I think it would be very good to have more places like this in the world (and particularly in Germany). Next, I would like to thank Dr. Iwata, who has not only taken care of my accommodation in the perfect way mentioned in the introduction, but also invited me to his home where his wife served an excellent Japanese dinner. Thanks to Dr. Hiroshige, I had a delicious

welcome lunch. Thanks to Dr. Hasegawa and the first lab I had a beautiful welcome party and was even able to enjoy playback singing in a typical Japanese bar.

Ken Satoh, Katsumi Inoue, Nicolas Helft and in particular Jun Arima were always around to answer any question, to show me where to eat (and how to eat with sticks), and to explain any aspects of Japanese life, culture, language or whatever to me. I am particularly indebted to Jun, who spent a whole weekend with me to explore eight different temples and shrines in Kamakura. He even gave me the opportunity to stay in his home overnight, where we also had an excellent dinner. And two days later he brought me a lot of beautiful pictures he had taken in Kamakura and in his home. These pictures will always remind me of the wonderful days I spent with him. Thank you, Jun.

It is an interesting psychological phenomenon that in situations which we do not like time seems to proceed very slowly. If, however, we feel happy and enjoy ourselves then time is just running. After spending almost three weeks in Tokyo I still feel as if I had just arrived. It is a simple case of abductive reasoning to conclude from this how I enjoyed my stay here. If someone asks me to express my feelings about my stay here in one sentence, I'd like to say: I came to ICOT as a colleague, I leave ICOT as a friend. Hope to see all of you again very soon.

Unfortunately, I was unable to learn more than just a few words of the beautiful Japanese language. But I felt obliged to learn at least one word, namely ARIGATO.



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*Curriculum Vitae*

G. Brewka, born 1955 in Regensburg, Fed. Rep. of Germany, studied philosophy and computer science at the University of Bonn. He received his diploma in computer science in 1984. He then joined Gesellschaft für Mathematik und Datenverarbeitung and was a member of the expert systems research group. In 1987 he joined the newly founded hybrid inference systems group (head F. di Primio). His main research interests are logical foundations of knowledge representation and inference, in particular non-classical inference. His thesis "Nonmonotonic Reasoning: From Theoretical Foundation Towards Efficient Computation" has been submitted to the University of Hamburg.

G. Brewka is married since 1979 and has three children.

*Main publications:*

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