VISITOR'S REPORT AT ICOT

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Period of visit: November 11 - 29, 1991 (except Nov. 18 - 21, which was spent at the combined International Symposium and Workshop on New Models for Software Architecture '91 and the 3rd Conference on Situation Theory and its Applications).

Talks given at ICOT: Nov. 13: "Predicate logic with flexibly binding operators and natural language semantics"
Nov. 26: "On the expressive power of natural language quantifiers"

Talk at the STA III workshop: Nov. 21: "A situation-theoretic representation of text meaning: anaphora, quantification and negation"

General impression

A visitor accustomed to the limited resources of a European university cannot fail to be impressed by ICOT. The sheer number of researchers working on the 5th Generation Computer Project, the massive concentration of human and technical resources, and the professional organization of the re-

search, the various laboratories, etc., are very impressive. Likewise, the fact that most of these researchers are employed by private companies and yet spend a number of years doing basic research on this public and non-profit project, is surprising and very positive to someone like myself, who is used to endless and often little rewarding discussions with companies about their support for basic research (an exception to this state of affairs is SICS in Stockholm).

During my stay at ICOT I have mainly seen some of the work going on in the 3rd Research Laboratory, which is aimed at developing software and languages for knowledge bases and knowledge representation. The researchers there are basically computer scientists, some specializing in (computational) linguistics and logic. Since I myself am basically a philosopher and logician, with some specialization in linguistics, but not a computer scientist, I am not really in a position to give informed comments on this research. Similarly, my own work, as presented in my three talks during the stay, seems to me not directly relevant to it, although there are obvious points of contact. Since I made this clear before accepting the invitation, I must compliment ICOT on their broad-minded view of basic research and their wide range of interests, also in areas outside those directly involved in the project. Nevertheless, it follows that this report will be rather brief and general. I will not attempt an overall estimation of the ongoing research programs, but only try to make some comments on parts of it which I understand and which relate to my own work.

Particular comments on research at ICOT

One general point of common interest, which unfortunately there has not been time to discuss in any detail during this period, concerns my work (jointly with Peter Pagin in Stockholm) on a new method for variable-binding in predicate logic (and a comparison with the variable-binding mechanisms of DRT and DPL), which is many ways is more adapted for natural language semantics than the standard method, and which was the subject of my first talk here. Given FGCP:s general commitment to predicate logic, I feel there might be some interesting connections here, and I hope to be able to study the eventual links between our method and logic programming in the future.

Dr. Kazumasa Yokota and Dr. Hideki Yasukawa have discussed with me and my fellow visitor Jerry Seligman the work in the 3rd laboratory around the new general-purpose language *QUIXOTE*, which integrates several recent trends: deductive and object-oriented databases, programming language for object-based databases, denotational semantics in terms of labeled graphs or

hypersets, modules, and situated inference. Personally, I am not qualified to assess this language (but cf. Jerry Seligman's report), except that it seems very useful for applications. Among the applications that have so far been made is an ambiguity solver for verb meanings in Japanese (S. Tojo and H. Yasukawa). The underlying theory of situated inference and temporal information involves an interesting combination of ideas relating to Reichenbach's classification of temporal reference with a version of situation theory using a notion of a (temporal) perspective. This seems to be particularly useful for describing tense and aspect of Japanese verbs.

The use of Situation Theory and Situation Semantics permeates all parts of FGCP that I have come in contact with. The conscious commitment to one particular semantic framework is, I believe, original for such a large project as FGCP. It is interesting to see the effects of this decision, both with respect to the assessment of the usefulness of the framework itself in practice, and to the adoption of this research policy. Clearly, the general ideas of STASS, with its emphasis on partial information, explicit interaction with the context, situated inference, etc., are very promising, and well suited to a project of the present type. Since there does not really exist a basic, text-book, body of STASS theory that can simply be applied as it is, a substantial amount of theoretical work on the framework is required of ICOT researchers. This, it seems to me, varies from a mere use of standard STASS terminology to original research in the field. For example, the above mentioned work on situated inference and temporal information contains an interesting version of STASS theory.

Perhaps the most advanced theoretical part of Situation Theory so far is the use made of Azcel's theory of hypersets, (and, more generally, his general theory of structured objects). The most wellknown example is Barwise and Etchemendy's work on self-referential propositions. Another deep and interesting application is being done at ICOT, namely, Dr. Kuniaki Mukai's work on the theory of constraint logic programming (CLP) using hypersets. In his recent paper "Bisimulations on generalized terms" and the paper "Unification in final coalgebras" presented at the STA III workshop, Mukai-san applies techniques from Azcel and Barwise to give a general treatment of the notion of a constraint and derives general versions of Colmerauer's results on infinite tree unification. The treatment is technically elegant and the notion of a constraint is clear and precise, in contrast with previous work in this field. This is high quality work in theoretical computer science. I have worked myself a little on Azcel's theory of structured objects, and it was

rewarding for me to learn about Mukai-san's research, and to talk about it with him. It turned out that our interests here had much in common. In particular, he suggested that my notion of an 'occurrence system' could be related to Aczel's notion of 'uniformity on maps', and possibly also be relevant for a more abstract treatment of CLP in terms of Aczel's replacement systems rather than hypersets. Although this was not a subject of my talks at ICOT, the conversations with Mukai-san on this matter were very fruitful and inspiring for me, and they established a contact which I am sure will continue in the future.

Another piece of ICOT research close to my own interests is Dr. Koiti Hasida's work on his Dynamical Logic for intergrated architecture of natural language processing. The starting point is the (well recognized) need for a tractable, declarative and constraint-based rather than procedural, computational framework which avoids as far as possible restrictions on the direction of information flow and which is tightly integrated with the formal semantics. In an early paper, "Reducing complexity of constraint-based grammars", Hasida-san applies his idea, if only marginally, to quantifier scope ambiguity. This relates to the work on a situation theoretic meaning representation I presented at the STA III workshop during my stay. In fact, my endeavour to give a compact meaning representation which embodies the 'core' of all the different readings of a sentence (or text) without having to represent these readings, is close in spirit to his attempt to account for scope with minimal use of syntactic structures. More precisely, my text meaning representations correspond to his "half-cooked interpretations" where only the basic ingredients of the interpretation and the various scoping possibilities are represented. There are also other similarities such as our common use of Gawron and Peters' treatment of referential noun phrases using restricted parameters and of their so-called Absorption Principle.

However, the main ideas of the Dynamical Logic are very far from being similar to any existing theory I know of. In fact, it is a highly original and interesting attempt to use dynamics in the sense of physics in natural language processing. Very roughly, the atomic parts of a constraint network are assigned initial values (real numbers between 0 and 1, to be thought of as degree of truth, or probability), as a function of which the whole network attains a potential energy (its 'degree of inconsistency' - or perhaps better degree of falsity), as the sum of various sorts of energies stipulated for the 'logical constants' in the network. The system then changes dynamically, to minimize the potential energy, and as it reaches equilibrium (a local minimum), can be inspected to

see what has happened to its various parts. One idea of this is that costly global consistency checks are not needed since local minima suffice, another is that the definitions of the various energies simultaneously give the declarative semantics and the inference control mechanisms of the system. Hasida-san has applied the theory to explain a number of familiar linguistic phenomena. The system is quite complex and not quite easy to understand from the recent paper describing it ("Dynamical logic for integrated architecture of natural language processing"), but the long discussions Hasida-san had with us did much to make things clearer. I believe more detailed comments on it can be found in Jerry Seligman's report. Although there are still problems with the system, not least because of its complexity, it seems to me that this is a new and potentially rich and powerful approach to natural language, or information, processing, and learning about it was a rewarding part of my stay here.

Apart from the 3rd laboratory, we also had brief presentations of the work in some of the other laboratories:

On November 27th, the work in the 5th Research Laboratory on theorem proving was presented to us, in particular, the use of the Model Generation Theorem Prover in solving Ramsey type partition problems, and the nearly linear speed-up obtained when the number of processors is increased.

On November 29th, Dr. Noboyuki Ichiyoshi from the 7th Research Laboratory gave an overview of the various parallel application projects currently being carried out in this laboratory, and Dr. Katsumi Nitta, chief of the laboratory, presented the interesting work on a legal reasoning system done by him and his colleagues.

Being at ICOT

In addition to the scientific part, the social aspect of being at ICOT for the past three weeks has been very pleasant. The research milieu is stimulating and warm, it is easy to talk to people, and the care taken of visitors is really excellent. Iwata-san has seen to it that the formal details of the visit went smoothly, almost un-noticeably, and Karakawa-san has been a constant source of help with practical matters, from finding books in the library to suggesting department stores or excursion goals. The welcoming lunch offered by the management of ICOT, Mr. Hiroshige, Dr. Fuchi, Mr. Kurozumi, Dr. Furukawa and Dr. Uchida, was also a pleasant occasion for a visitor, and

I would like to thank all of these persons. It should be emphasized that the conditions offered to visitors at ICOT are very generous and encouraging.

Furthermore, the reception from my hosts at the 3rd laboratory, in particular, Mukai-san, Yokota-san, Yasukawa-san, Hasida-san and Tsuda-san, has been outstanding. They managed to maintain a perfect balance between taking care of you so that you don't feel lost, but also letting you explore things on your own. In particular, I would like to thank Hasida-san for his efforts to make me feel at home here (and to introduce us visitors to the rich variety of Japanese cuisine), and Mukai-san for his warm hospitality and his company for a whole day of walking around in Kamakura.

Tokyo, November 29, 1991

Dag Westerståhl

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CURRICULUM VITAE
September 1991

Education

1967	BA, Univ. of Gothenburg.
1977	Ph. D. in theoretical philosophy, Univ. of Gothenburg.
1983	'Docent' in theoretical philosophy, Univ. of Gothenburg.

Employment

1978 - 1984	Assistant professor ('forskarassistent') in practical and theoretical philosophy, Univ. of Gothenburg.
1984 - 1988	Associate professor ('universitetslektor') in philosophy, Univ. of Gothenburg.
1984 - 1986, 1988 - 1990	Researcher ('forskare'), Swedish Council for Research in the Humanities and Social Sciences (HSFR).
1986	Visiting research associate, Center for the Study of Language and Information (CSLI), Stanford University.
1988 -	Associate professor ('högskolelektor') in theoretical philosophy, Stockholm University.
1991 - 1993	Senior researcher ('forskardocent') in philosophy och language, HSFR.

Commissions

1977 - 1981	Director of studies, Dept. of Philosophy, Univ. of Gothenburg.
1981 - 1988	Chairman, Dept. of Philosophy, Univ. of Gothenburg.
1988 -	Secretary of the National Committee of Logic, Philosophy and Philosophy of Science, of the Swedish Royal Academy of Sciences.
1990 - 1991	Secretary of the Organizing Committee of the 9th International Congress of Logic, Methodology and Philosophy of Science, Uppsala, August 7-14, 1991.

Visiting Scholar

1985/86	Visiting Scholar, CSLI, Stanford University.
1985/86	Consultant, Xerox Palo Alto Research Center, Palo Alto.

Scientific Associations

Member of the Association for Symbolic Logic.

Editorial board

1991 -	Member of the editorial board of the Kluwer publication series *Studies in Logic, Language and Information.*