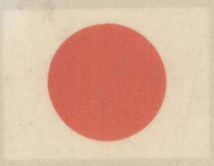
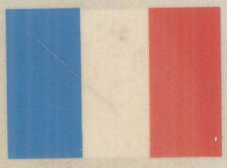
Programming of Future Generation Computers



ICOT



INRIA

K. Fuchi and M. Nivat
Editors

North-Holland

PROGRAMMING OF FUTURE GENERATION COMPUTERS

Proceedings of the First Franco-Japanese Symposium on Programming of Future Generation Computers Tokyo, Japan, 6–8 October, 1986

Edited by

K. Fuchi

ICOT
Minato-ku
Tokyo, Japan

M. Nivat

University Paris 7 and INRIA
Paris, France

1988

NORTH-HOLLAND
AMSTERDAM · NEW YORK · OXFORD · TOKYO

ISBN: 0 444 70410 8

Published by:
ELSEVIER SCIENCE PUBLISHERS B.V.
P.O. Box 1991
1000 BZ Amsterdam
The Netherlands

Sole distributors for the U.S.A. and Canada:
ELSEVIER SCIENCE PUBLISHING COMPANY, INC.
52 Vanderbilt Avenue
New York, N.Y. 10017
U.S.A.

LIBRARY OF CONGRESS
Library of Congress Cataloging-in-Publication Data

Franco-Japanese Symposium on Programming of Future Generation Computers (1st : 1986 : Tokyo, Japan)
Programming of future generation computers : proceedings of the First Franco-Japanese Symposium on Programming of Future Generation Computers, 6-8 October, 1986, Tokyo, Japan / edited by K. Fuchi, M. Nivat.
p. cm.
ISBN 0-444-70410-8 (U.S.)
1. Electronic digital computers--Programming--Congresses.
2. Fifth generation computers--Programming--Congresses. I. Fuchi, Kazuhiro. II. Nivat, M. III. Title.
QA76.6.F7227 1986
005.1--dc19 88-7129
CIP

PRINTED IN THE NETHERLANDS

PROGRAMMING OF FUTURE GENERATION COMPUTERS

FOREWORD

The cooperation of researchers in many countries will make it possible to enter a new age of information processing. The French and Japanese governments decided to accelerate the movement towards this new age by exchanging the results of recent research in this field. As a result of this decision, the first symposium was held in Tokyo from October 6th to 8th, 1986.

The papers in this collection are revised versions of those presented at the France-Japan Artificial Intelligence and Science Symposium '86. As suggested by the title, the contents of the papers cover apsects of artificial intelligence and computer science.

The following sessions were held at the symposium.

Session A: Fifth Generation Programming Languages, Methodologies and Environments

Session B: Models and Programming Languages for Parallelism

Session C: Automated Deduction and Symbolic Computation

Session D: Machine Architectures Dedicated to Fifth Generation Languages

Session E: Expert Systems and Natural Language Understanding Systems

Fifth generation programming languages reported in session A included constraint logic programming language and a term rewriting system. A new method for interfaces for deductive data bases was also proposed.

In session B, Guarded Horn Clauses (GHC), a concurrent logic language and QJ, a constructive logic system, were introduced. Esterel, a language using functions for describing interaction with the external world in procedural language, was also introduced.

In session C, one paper on constructive theory, two on program verification, and two on Prolog were presented.

In session D, two papers on architecture for functional languages, one on real-time garbage collectors for sequential Prolog, and one on the Multi-PSI, a small-scale parallel inference machine for parallel logic languages, were presented.

In session E, two papers on expert systems and three on natural languages were presented.

This symposium was the first held by the French and Japanese governments, and the quality of the papers was very high. I hope that this collection of papers will promote further exchange between our two countries and contribute to world progress in the field of artificial intelligence and computer science.

Kazuhiro Fuchi
Director, Research Center
Institute for New Generation Computer Technology

FOREWORD

今、我々は、豊かな情報化社会の入口に到達したところであるが、この流れを加速するには、情報処理の新しい技術を創造していくことが不可欠である。そして、それは、世界諸国の研究者の協力があって、初めて可能となるであろう。そのような協力の一環として、この分野の先進的な研究成果を交流することが、仏日両国の政府によって合意された。

昭和61年10月 6日～ 8日の 3日間、その合意に基づいた第一回のシンポジウムが東京で開催された。

この論文選集は、「France-Japan Artificial Intelligence and Computer Science Symposium 86」と名付けたシンポジウムでの発表内容を基にし、より洗練された論文を集めたものである。

発表内容は、そのタイトルが示す如く、人工知能とコンピュータ・サイエンスの分野の話題が集められている。

シンポジウムはつぎの５つのセッションに分けられた。

（Ａセッション）：5th Generation Programming Languages, Methodologies and Environments

（Ｂセッション）：Models and Programming Languages for Parallelism

（Ｃセッション）：Automated Deduction and Symbolic Computation

（Ｄセッション）：Machine Architectures Dedicated to 5th Generation Languages

（Ｅセッション）：Expert System and Natural Language Understanding System

（Ａ）セッションでは、5th Generation Programming Language として、制約型論理プログラミング言語、項書換えシステムなどの話題が発表された。また、演繹データベースのインタフェースについての新たな方式が提案された。

（Ｂ）セッションでは、並列モデル／言語として、concurrent logic language の一種であるGuarded Horn Clauses (GHC)、および構成的論理システムQJが紹介された。さらに、手続き型言語に外界との相互作用を記述するための機能を導入した言語Esterel が紹介された。

（C）セッションでは、構成的型理論に関する論文が２件、プログラムの検証に関する論文が２つ、Prologに関する論文が２つ、発表された。

（D）セッションでは、関数型言語のためのアーキテクチャに関する論文が２件、逐次Prologのためのリアルタイム・ガーベッジ・コレクタに関する論文、および並列論理型言語のための小規模並列推論マシンMulti-PSI に関する論文の計４つが発表された。

最後の（E）セッションでは、エキスパート・システムに関する論文が２件、自然言語に関する論文が３件発表された。

本論文集は、会議と同じセッション構成により編集されている。

本シンポジウムは、初めての試みであるが、質の高い論文を集めることができた。これが、仏日両国の研究交流をさらに推進し、また、この分野の世界の進歩に寄与するものとなれば幸いである。

渕 一博

渕　一博

ＩＣＯＴ研究所長

FOREWORD

The Japanese Fifth generation computers project, launched in 1981, has already played a major role concerning the orientations and objectives of Research in Computer Science all over the world.

This project is indeed an ambitious and complex one: its aim is to let mankind enter a new era of Information technologies, in which intelligent computers will be adapted to all human activities, including the activities of the most disadvantaged sections of the population, those who are handicapped by age or malady. Human intelligence has many facets and that is why the Japanese project had to be multiple in order to design both hardware and software systems able to reason i.e. to deduce, from a base of knowledge and a set of rules, consequences which can be translated into action. The first problem is to think about the nature of knowledge and understand the mechanisms of reasoning by which men can draw conclusions from their knowledge and take decisions in a given situation.

Of course the idea is not new: as far back in time as the seventeenth century the logicians of Port-Royal, Antoine Arnauld and Pierre Nicole, in their book "La logique ou l'art de penser" were proposing rules in order to "draw from imperfect knowledge facts which can be considered as certain". Their main aim was likely to show how every human being, as imperfect as his knowledge can be, may convince himself that God exists: it is, however, extremely interesting to see how close some of the rules they give are to rules of modern expert systems.

What is new is the extraordinary power of the most recent computers and the huge amount of experience accumulated in thirty years of research on programming. These two facts allow us to believe that substantial progress can be achieved in the mechanization part of human reasoning and even more substantial progress can be achieved in the adaptation of computer tools to human activity. Only a very good integration of these new computer tools to the whole set of old and new tools man uses to think, work, or perform actions will allow the Society, when in the new era of Information technology, to be more just: some painful tasks will be carried by the intelligent computers and better communication means will efficiently fight isolation and ignorance.

All computer scientists in the world have welcomed the Fifth generation computer project and they have also considered, with the greatest interest, the creation of ICOT, the institute created by the Japanese government in connection with a number of great industrial firms. In only a few years ICOT grew into a remarkable laboratory in which the skill and competence of researchers, among whom many are very young, meet a clearly and firmly stated will to obtain results on objectives which interest everybody. The problems are so many and difficult that the research to solve them has to be conducted on a world scale. This is why the French and Japanese governments agreed to link the two institutes ICOT and INRIA, the older French institute which this year celebrated its 25th anniversary. INRIA was also created to solve the innumerable problems raised by the development of Informatics, Automatics, and all the branches of Information technology, and is generally considered to be one of the best laboratories in Computer Science in the world.

Cooperation can only be established on a good knowledge by each partner of what the other one is doing, and by searching: thus the first manifestation of the desire for cooperation between our two countries has been the Franco-Japanese seminar held in Tokyo in 1986, and the present proceedings volume.

Undoubtedly this seminar has been an exceptionally rich occasion of meeting and exchanging ideas. We are very happy to offer to the scientific community the present volume, and hope that it will inspire other work and help the progress of Computer Science and Technology in the world.

Maurice Nivat

FOREWORD

Le projet Japonais de 5ème génération d'ordinateurs, lancé en 1981, a déjà joué un rôle considérable en ce qui concerne les orientations et les objectifs de la Recherche en Informatique dans le monde entier.

Le projet est ambitieux et multiple: le nouvel âge du traitement d l'information dans lequel ce projet s'est donné pour but de faire rentrer l'humanité sera celui des ordinateurs intelligents et adaptés à toutes les activités humaines y compris celles des plus défavorisées de nos semblables, ceux qu'handicapent l'âge ou la maladie. Les ressorts et les manifestations de l'intelligence humaine sont multiples et variés et cela impliquait que le projet fût multiple: car il s'agit bien de concevoir et réaliser des machines et des logiciels susceptibles de raisonner, c'est-à-dire à partir d'une base de connaissances et d'un ensemble de règles déduire des conséquences qui se traduisent en action. Le projet japonais nous invite d'abord à une réflexion sur ce qu'est la connaissance, la façon de l'acquérir, de l'enregistrer et de la transmettre et sur les mécanismes du raissonnement qui permettent à l'homme de tirer des conclusions et de prendre des décisions face à une situation donnée.

En un sens le projet n'est pas nouveau: dès le 17ème siècle les logiciens de Port Royal, Antoine Arnauld et Pierre Nicole, dans la logique ou l'Art de penser, proposaient un certain nombre de règles, "pour tirer d'un ensemble de connaissances incertaines de faits que l'on puisse tenir pour certains". Et s'ils songeaient d'abord à montrer comment tout honnête homme, si imparfaites que soient ses connaissances, doit conclure à l'existence de Dieu, certaines de leurs règles ressemblent beaucoup à celles qu'utilisent nos modernes systèmes experts.

La nouveauté c'est l'extraordinaire puissance des ordinateurs modernes et l'acquis considérable de 30 ans de recherche sur la programmation. Ces deux faits rendent le projet crédible, du moins rendent crédible l'idée que l'on fasse des progrès substantiels vers la mécanisation d'une partie du raisonnement humain et des progrès encore plus substantiels vers l'adaptation de l'outil informatique à l'homme. C'est l'intégration de l'outil informatique à la panoplie de tous les outils issus de la technologie moderne qui permettra de construire une société nouvelle et plus juste, par un allègement du fardeau des tâches pénibles et par une amélioration des moyens de la communication qui diminuera les phénomènes d'isolement et d'ignorance.

Les informaticiens du monde entier ont accueilli avec un extrême intérêt ce projet et ont vu se créer avec tout autant d'intérêt, l'ICOT, l'institut crée par la gouvernement japonais pour poursuivre, en liaison étroite avec de grands groupes industriels la recherche sur ce sujet. D'autant plus qu'en quelques années l'ICOT est devenu un très remarquable laboratoire de recherche, dans la mesure où la compétence de nombreux chercheurs, dont certains très jeunes, rencontre une volonté très clairement et fermement exprimée d'avancer vers la réalisation d'objectifs auxquels personne ne peut rester insensible. L'ampleur de l'effort à fournir fait que cette recherche ne peut être conduite qu'à l'échelle planétaire. C'est ainsi que les gouvernements français et japonais sont tombés d'accord pour lier les efforts poursuivis par l'ICOT et l'INRIA, l'Institut créé en France en 1967, pour faire face précisément aux multiples problèmes que soulèvent le développement de l'Informatique de l'Automatique et de toutes les techniques de traitement de l'information. L'INRIA est très généralement considéré comme un des grands laboratoires mondiaux d'Informatique.

Comme toute coopération ne peut s'établir que sur une bonne connaissance par chacun de ce que fait et cherche l'autre la première manifestation de la volonté de coopération des deux gouvernements, en ce domaine, a été la tenue du colloque dont les actes forment le présent volume.

Il ne fait pas de doute que ce colloque a été pour tous les participants un lieu de rencontre et d'échange d'une exceptionnelle richesse. Nous sommes très heureux d'offrir à la communauté scientifique ce compte-rendu de ses travaux, dans l'espoir qu'il en suscite d'autres, et aide à faire progresser la science et la technologie informatiques dans le monde entier.

Maurice Nivat

ACKNOWLEDGEMENTS

On behalf of INRIA and ICOT, the organizers of this first France-Japan Symposium acknowledge the help of the Japanese Ministry of International Trade and Industry (Electronics Policy Division) and the French Ministry of Foreign Affairs (Cultural, Scientific and Technological Cooperation Division) for their support, without which the symposium could never have been held.

They also thank all the Japanese and French Research Institutes for allowing some of their members to participate and contribute to the success of this meeting.

CONTENTS

Programming of Future Generation Computers
K. Fuchi, M. Nivat (Editors)
Elsevier Science Publishers B.V. (North-Holland), 1988

A New Parallel Graph Reduction Model and Its Machine Architecture

Makoto Amamiya

NTT Electrical Communications Laboratories
3-9-11 Midoricho Musashino-shi Tokyo 180 Japan

Abstract

A new parallel graph reduction model and its machine implementation are discussed on the basis of data flow scheme. First, a parallel graph reduction model, named G-reduction, is presented. In the G-reduction system, reductions proceed on the data flow graph. Then, a parallel reduction machine is presented as a practical implementation of the G-reduction mechanism. In the implementation, a cell token flow concept is used. In the cell token flow model, variable cells, instead of data, flow in the data flow graph. The cell token flow model solves several weak points of the data flow architecture, such as the overhead of flow control, lack of history sensitive computation, lazy evaluation and higher order function facilities. Using the cell token flow concept, a given data flow graph can be optimized, and a multi-thread control flow can be extracted from the data flow graph. Last, a design of the reduction machine is presented. The machine is designed on the basis of packet communication concept, in which many processor and memory resources are connected with packet communication network. The processor is a circular pipeline system, which can execute a large number of function activations concurrently due to its pipeline structure.

1. Introduction

Recently, several models are proposed and discussed on the reduction mechanism and its machine architecture[1-6]. When we think of the reduction model, we should notice that the reduction model itself never gives us the control of execution, but it only specifies the mechanism of computation by reduction concept, that is, the mechanism in which a given expression is reduced to some value. The reduction model is abstract, and therefore, beautiful in the theoretical sense. However, if we wish to implement the reduction model as a practical machine, it is very difficult to get the solution of machine architecture from the reduction mechanism only.

The control in the reduction model is the reduction strategy, i.e., the order of reduction. There considered two schemes as to the redution order. The one is the serial reduction (totally ordered), and the other is parallel reduction (partially ordered). The well known concepts of reduction strategy are normal order reduction and applicative order reduction.