LOGIC PROGRAMMING NEWSLETTER

1

PRIMAVERA DE 1981 / SPRING 1981 **DISTRIBUIÇÃO GRATUITA / FREE DISTRIBUTION**

CONTENTS

EDITOR

Prof. Luís Moniz Pereira
Departamento de Informática
da Universidade Nova de Lisboa

PUBLISHED

UNIVERSIDADE NOVA DE LISBOA
Departamento de Informática
Quinta do Cabeço — Olivais
1899 Lisboa Codex
Portugal
Tels. 251 25 26 ● 251 26 60 ● 251 25 55

DESIGN, TYPESETTING AND PRINTING

Serviços Gráficos da Universidade
Nova de Lisboa
Av. Miguel Bombarda, 20-1.º
1000 Lisboa

EDITOR'S FOREWORD

At the first Logic Programming Workshop, held at Debrecen, Hungary, July 1980, it was decided to promote a Logic Programming Newsletter, to be issued at least twice a year. It was also decided that it would be edited in Lisbon, and Luís Moniz Pereira was appointed editor. The aim of the newsletter is to improve communication and cooperation among the Logic Programming Community as well as to divulge its ideas and achievements to a wider audience.

The newsletter will be sent free of charge to those soliciting it from the editor. However, to keep the newsletter free of charge, avoid soliciting it from the editor if you have easy access to a library or someone receiving it.

How can you participate?

(1) It would be useful if each group with an interest in logic programming chose one representative in charge of:

- *keeping the editor informed of local news*
- *pressing the group for contributions*
- *direct contact with the editor regarding any urgent matters.*

So, choose your representative and send his name, address and telephone number to the editor as soon as possible.

(2) Here's a list of different possible types of contribution (perhaps you will think of others):

- *short communications on your work*
- *reviews of other people's work*
- *abstracts of reports: send a report*
- *reports on conferences attended and visits to other groups*
- *personal news (posts, changes of address, etc.)*
- *exchange of posts and posts available*
- *description of grant proposals and contracts*
- *illustrative programs to be included in the Newsletter or in the next edition of «How to solve it with Prolog», a compilation of Prolog programs*
- *description of your research and development aims, including your policy regarding the institutional setting*
- *start a debate (eg. which syntax for Prolog?)*
- *comparison of Logic Programming with other programming languages*
- *implementation description and evaluation*
- *what you would like to see in the newsletter*
- *addresses of practioneers*
- *listing of papers published in journals and conferences (send your list).*

(3) Contributions may be sent directly to the editor or through your representative.

They should fit, with regular margins, on standard size A4 paper (this size). Write in English, on one side only, with the spacing not endangering legibility, either typewritten or printed on the computer.

The editor thanks António Porto and Eugénio Oliveira for helping in producing this issue, and acknowledges the financial suport of the «Junta Nacional de Investigação Científica e Tecnológica» through the «Centro de Informática da Universidade Nova de Lisboa».

The next number will be out as soon as there are enough contributions. Please contribute generously.

The Editor
LUÍS MONIZ PEREIRA

Summary of
EFFICIENT LOGIC PROGRAMS: A RESEARCH PROPOSAL

John S. Coery
Paul H. Morris
Dennis F. Kibler

Dept. of Information and Computer Science
University of California, Irvine

5 February 1981

The goal of the proposed research is to develop methods for efficient implementation of logic programs. There are two areas we wish to investigate, both of which are continuations of research conducted by members of the UCI Dataflow Architecture group. One aspect of the proposed research involves development of a non-von Neumann architecture for parallel execution of logic programs, preliminary work in this area is reported by Conery [3]. The second area involves transformation of high level logic specifications into efficient Prolog and/or procedural language programs, and is based on work by Morris [7].

1. A Parallel Processor for Prolog

One possible configuration of a multiprocessor machine for logic programs is to have all processors work on the same goal list, i.e. replace DECsystem-10 Prolog's depth-first search with some parallel search method. This is the approach implied by Kowalski («Algoritm = Logic + Control») [5], and by Nilsson [8], where Petri nets are mentioned as possible parallel control structures for production systems.

A major difficulty with this approach is possible conflicting assignments for variables that could be generated by unifications in different branches of the search tree. The problem is one of simultaneous access to common memory by processes executing in parallel. This problem is avoided in data-driven systems (c.f. Arvind, Gostelow, and Plouffe [1]).

The attached figure shows a tree, where each node contains a goal list, and descendants of a node are obtained via one unification-and-replacement step. What we propose is a data-driven machine that would process independent branches of the tree using independent processors. The data passed between processors would be goal lists; thus our machine is more properly called a goal-driven processor.

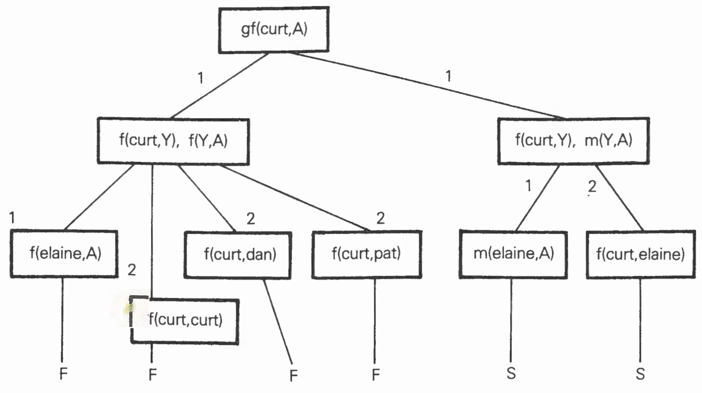
Among the issues to be resolved are

— Strategies for creating the tree. The figure shows two possibilities: one very ambitious and wasteful of processors, and another that is close to Prolog's search tree. Are there any other strategies? Which is best? What runtime information can be used to create more efficient search trees? (Work by Clark and McCabe [2] on ordering subgoals and co-routining is relevent here.)

— Methods for allocating processors to goal lists. When a processor has expanded a node, what does it do next? Can it work on a completely independent branch, or should it confine itself to one of the just-created goals? What happens when all of the processors have been allocated?

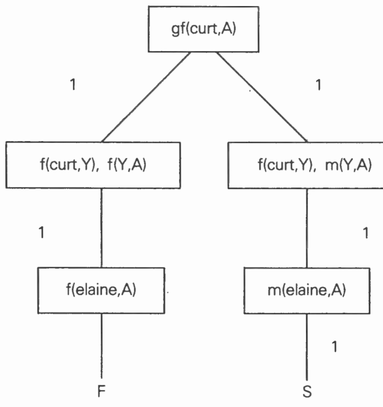
— Methods for communicating results back to the processor that originated search.

The proposed research program is a «top-down» approach, moving from hand simulations to programmed simulations of an abstract machine (on the order of the Irvine Dataflow base machine) to simulations of a physical multiprocessor machine. This last machine could very well have the same architecture as the Irvine Dataflow machine [4].



The numbers labelling arcs refer to the goal within the parent that is used to create the descendant

Figure 2-3: Maximum Breadth-First Goal Tree



A less ambitious strategy for expanding nodes uses only the first goal in the current list (i.e. every label is 1)

Figure 2-4; Breadth-First Goal Tree

2. Optimization of Logic Programs

The goal of this research segment is to attain a certain level of automatic programming, using logic programs as an intermediate language for manipulation. Specification will be in a high-level declarative language which resembles the recursion equation of Manna and Waldinger [6]. Conversion to efficient code will proceed in four stages:

— Straight-forward translation to a (probably inefficient) logic program.

— General transformations to remove some well-defined types of inefficiency, using the dataflow network representation of logic programs [7]. This version of dataflow is oriented towards manipulation, rather than direct implementation, and differs somewhat from both Irvine dataflow and the relational dataflow system [3].

— Further optimization based on runtime information.

— Straight-forward translation to a conventional language.

REFERENCES

1. ARVIND, GOSTELOW, K. P., and PLOUFFE, W. P.: An Asynchronous Programming Language and Computing Machine. Technical report 114a, Dept. of Information and Computer Science, University of California, Irvine, December, 1978.
2. CLARK, K. L., and G. McCABE: The Control Facilities of IC-Prolog. In D. Michie, Ed., *Expert Systems in the Micro Electronic Age,* Edinburgh University Press, 1979.
3. CONERY, J. S.: A Relational Dataflow System. Dataflow Note 48a, dept. of Information and Computer Science, University of California, Irvine, May, 1980.
4. GOSTELOW, K. P. and R. THOMAS: Performance of a Simulated Dataflow Computer. *IEEE Transactions on Computers C-29,* 10 (October 1980), 905-919.
5. KOWALSKI, R. A.: Algorithm = Logic + Control. *Comm. ACM 22,* 8 (July 1979), 424-436.
6. MANNA, Z. and WALDINGER, R.: A Deductive Approach to Program Synthesis. *ACM Transactions on Programming Languages and Systems 2,* 1 (January 1980), 90-121.
7. MORRIS, P. M.: A Dataflow Interpreter for Logic Programs. Dataflow Note 50, Dept. of Information and Computer Science, University of California, Irvine, May, 1980.
8. NILSSON, N. J.: *Principles of Artificial Intelligence.* Tioga Publishing Company, Palo Alto, Ca., 1980.

Please notify us of any related work.

A NEW PROPOSAL FOR CONCURRENT PROGRAMMING IN LOGIC

Luís Monteiro
Departamento de Informática
Universidade Nova de Lisboa
1899 Lisboa Codex
PORTUGAL

We outline in this note a proposal for an extension to Horn clause predicate logic (HCL, for short) such that, when sets of clauses are interpreted as programs as originally suggested by Kowalski [7, 8], the entire execution of a given program may be viewed as the concurrent execution of several of its parts. This extension consists, on the one hand, in providing an explicit notation to distinguish between processes that run concurrently from processes that run sequentially, and, on the other hand, in introducing a construct for process synchronization. It is hoped that this extension will not betray the essential spirit of HCL programming. For example, we required from the outset that our system should possess equivalent operational and declarative semantics, as is the case with HCL and in fact one of its more distinctive features [3]. Unlike some other works that have appeared recently and which try to enlarge HCL programs so as to include some notion of concurrency [1, 2, 5, 6], our system seems to be the only one to be defined entirely in logical terms. It is not the purpose of this note, however, to compare our system with these other systems issuing from HCL or, for that matter, with any other system for expressing concurrency. For reasons that will be apparent later, we call (provisionally) our system "state description logic" or SDL, for short.

When referring to HCL notions we shall in the main follow Kowalski's terminology and notation [7, 8], with one difference: identifiers starting with a lower case letter denote (individual) constants or predicate or function symbols, while identifiers starting with an upper case letter denote (individual) variables.

State descriptions are defined in the following way:

— the symbol '□' and every atom A are state descriptions;
— if S and T are state descriptions then so are S.T and S+T.

State descriptions are supposed to satisfy the following equations:

$$\Box.S = S.\Box = S, \qquad \Box+S = S+\Box = S,$$
$$R.(S.T) = (R.S).T, \qquad R+(S+T) = (R+S)+T.$$

Thus state descriptions have a structure which we might call a "bi--monoid". Parenthesis are eliminated in the usual way and also by assigning higher priority to '.' than to '+'.

In the absence of the synchronization construct, state descriptions may be used to generalize clauses in the following way. A "generalized clause" is of either of the forms ←S or A←S, where A is an atom and S is a state description. Declaratively, '□' is interpreted as 'true' and both '.'and '+' are interpreted as conjunction. Operationally, '□' means 'end of process', 'S.T' means that the process initiated by S must be completed before the process with origin T starts, and 'S+T' means concurrent execution of the processes with origins S and T.

Let us now be more specific about the operational semantics. We shall write a generic state description S in the form $S_1+...+S_n$, $n \geqslant 0$, where no S_i is either □ or S'+S'' for some state descriptions S' and S''; we assume that S = □ iff n = 0. In this case every S_i has the form $S_{i_1}.....S_{i_{n_i}}$ where no S_{i_j} is either □ or S'.S''. If each S_i is an atom A_i we shall say the state description $S=A_1+...+A_n$ is *flat.*

We associate with each state description S a flat state description front (S) defined recursively as follows:

- front (S) = S if S is either □ or an atom;
- front (S.T) = front (S) and front (S+T) = front(S)+front(T)

if S and T are state description distinct from □.

We are now in a position to state precisely the notion of "direct derivation". As a first aproximation, the notion that ←S derives ←T, where S and T are state descriptions, is precisely as in HCL [7, 8], with the sole difference that the atom selected in S for resolving with a clause of the logic program is in fact selected in front (S). The next step will be to allow several atoms in front (S) to be resolved simultaneously. With this notion of direct derivation it is easy to define the operational semantics of this system as for HCL. The equivalence between the declarative and the operational semantics follows from a result by Hill [4].

We view a state descriptions $S=S_1+...+S_n$ as a description of the state of a process, which consists in n processes running concurrently, and described in the present state by $S_1,...,S_n$ respectively. Each of these n processes may itself consist of several processes running concurrently, and so on, depending on the way S is structured in terms of '.' and '+'. What is lacking is a mechanism to synchronize these processes.

We enforce synchronization by organizing the (generalized) clauses into sets and requiring that, in a direct derivation from ←S to ←T, if some clause C is used then the remaining clauses belonging to the same set as C must also be used. Put in another way, let us suppose that $A_1 \leftarrow S_1,..., A_n \leftarrow S_n$ is one of the distinguished sets of clauses. This set may be represented by the expression

$$A_1,...,A_n \leftarrow S_1,...,S_n$$

called an *implication,* and we assume that $A_{i_1},...,A_{i_n} \leftarrow S_{i_1},...,S_{i_n}$ is the same implication if $i_1,...,i_n$ is a permutation of 1,...,n. An SDL program is a finite nonempty set of implications. The definition of a direct derivation from ←S to ←T is the same as before with the sole difference that we now use implications instead of (generalized) clauses. The operational semantics now follows in the usual way: a state description S is a logical consequence of a given SDL program iff ←S derives ←□. (The variables of S are assumed to be existentially quantified.) Notice that in a SDL program P a state description A+B may be a logical consequence of P without A or B being logical consequences of P (consider for example the program A,B←□,□). Thus the semantics of SDL programs must be described in terms of state descriptions and not of atoms, as is the case for HCL programs. Another new situation we must consider is the possibility of some processes being infinite yet meaningfull. In this case we shift our attention from the notion of logical consequence to the notion of derivability (of which, as a matter of fact, the notion of logical consequence is a particular case).

As an example of an SDL program (taken from [10]) let us consider a resource and two objects 'a' and 'b', each using the resource in some phase of its activity, with the restriction that the objects cannot use the resource simultaneously. The initial state description and the program follow:

```
← object(a,ownactivity)+resource(available)+object(b,ownactivity)
   object(X,ownactivity) ← object(X, requests)
   object(X,requests),  resource  (available) ← Object(X,uses),resource
                                                                 (taken)
   object(X,uses) ← object(X,releases)
   object(X,releases),  resource(taken) ← object(X,ownactivity),resource
                                                          (available)
```

Another program for the same problem, more adequate for other purposes, is the following:

```
← object(a)+resource+object(b)
   object(X) ← ownactivity.requests.uses.releases.object(X)
   resource ← available.taken.resource
   ownactivity ← □
   requests,available ← □ , □
   uses ← □
   releases,taken ← □ , □
```

To define the declarative semantics of an SDL program we need the notion of an interpretation. Let F and P be the sets of function symbols and predicate symbols respectively occurring in the program. Let BM(P) be the free bi-monoid generated by P. Each element s in BM(P) has an arity which is the sum of the arities of the predicate symbols ocurring in s. Now an *interpretation* of the SDL program is any F-algebra A together with a mapping from BM(P) to the set Pred(A) of all predicates over A. This function must satisfy some requirements, such as the one of preserving arities (and some others as well). A "valuation" is as usual a function mapping variables onto elements of A. It is then possible to define the usual notions of "satisfaction" of a state description or an implication, of "models", "Herbrand models" and of a state description being a "semantic consequence" of the SDL program. It can also be proved that the operational and the declarative semantics are equivalent.

The work outlined herein will be the subjet a series reports dealing systematically with a general presentation of the system, the proof of the equivalence between the operational and the declarative semantics, and the presentation of an experimental interpreter for this system written in Prolog.

(This note is a slightly revised version of an extended abstract [with a different title] submitted to the International Colloquium on Formalization of Programming Concepts, to be held in Peñiscola, Spain, in April 1981. The work was supported by the Instituto Nacional de Investigação Científica, through the Centro de Informática da Universidade Nova de Lisboa.)

REFERENCES

1. K. CLARK, F. McCABE, The Control facilities of IC;-Prolog, Dept. of Computing and Control, Imperial College, 1979.
2. M. DAUSMANN, G. PERSCH, G. WINTERSTEIN, Concurrent Logic, Univ. Kaiserslantern, 1979.
3. M. van EMDEN, R. KOWALSKI, The Semantics of Predicate Logic as a Programming Language, JACM 23 (1976), 733-742.
4. R. HILL, Lush resolution and its Completeness, Dept. of A. I., Univ. of Edimburgh, 1974.
5. C. HOGGER, Logic representation of a Concurrent Algorithm, in 9.
6. K. KAHN, Intermission-Actors, in 9.
7. R. KOWALSKI, Predicate Logic as a Programming Language, Proc. IFIP 1974.
8. R. KOWALSKI, Logic for Problem Solving, North-Holland-Elsevier, New York, 1979.
9. S.-A. TARNLUND (Ed.), Proceedings of the Logic programming Workshop, Hungary, 1980.
10. WINKOWSKI, An Algebraic Description of Discrete Processes and Systems, Polish Academy of Sciences, 1980.

TRANSPORTING VALUES VIA RELATIVE ASSERTIONS

Paul Morris

Dept. of Computer and Information Sciences,
University of California, Irvine

Interative loops are a frequently used construct of conventional programming languages. An interesting property of iteration is that, in terms of data paths, the entrances and exits are at opposite ends of the loop. By contrast, in a recursively defined loop, both entrances and exits are at the top. For recursively defined functions, the functional value is available to pass at least one result back up the loop. In a relational language such as PROLOG, however, additional arguments are required to pass back results. Thus the PROLOG version of efficient reverse

```
reverse (X,Y) :— reversel (X,[],Y).

reversel ( [X,..Y],Z,W) :— reversel (Y,[X,..Z],W).
```

requires three variables to implement the loop, while the iterative program

```
procedure reverse(X);
local   Y <— [];
while   X   = [] do
        Y <— cons(car(X),Y)
        X <— cdr(X);
return Y;
```

requires only two. We argue that our mental represention of loops allows entrances and exits from both ends, and that the additional variables are an unnecessary obfuscation of this mental image.

We propose a new construct for PROLOG which will allow loops to be accessed from both ends, without the need for transporter variables. We do this by allowing PROLOG procedure calls to include what may be regarded as "temporary assertions" which are valid for the scope of the procedure call. We will call these *relative assertions*. A call P with relative assertion Q is denoted P/Q (some versions of PROLOG use the symbol "/" to denote what is called "cut" in DEC-10 PROLOG. We apologize for any confusion this may cause; the slash symbol seemed irresistably suited for conveying the notion of relative assertion) and may be read as "P given Q" or "P is deducible from Q." The expression may perhaps be assigned a declarative meaning as Q implies P, although, properly speaking, it is a condition in the metatheory. Observe that the procedural interpretation here is quite different from that of the "implies" in

```
subset(X,Y):— (member(Z,X) implies member(Z,Y)).
```

A definition of "/" for current interpreted DEC-10 PROLOG follows, together with its use in defining the reverse and concat predicates. By separating out the termination conditions from the loops, we potentially increase the reusability of the loop definitions. Notice that with this definition, recursive calls on slash will stack the relative assertions, i.e. they are local to the particular invocation of slash. Thus relative assertions could be used to maintain an environment across several levels of procedure call, giving the equivalent of dynamic scoping.

The definition below cannot be used in compiled code since compiled clauses are not accessible as data structures. We hope, however, that it will prove useful and that implementers will thereby be prompted to provide it at a more basic and efficient level of their system.

Definition and examples:

```
P/P :— !.
true/A :— !.
(P,Q)/A :— !, P/A, Q/A.
P/A :— clause(P,Q), Q/A.

c([X,..Y],,[X,..Z]) :— c(Y,Z).

concat(U,V,W) :— c(U,W)/c([],V).

r([X,..Y],Z) :— r(Y,[X,..Z]).

rev(X,Y) :— r(X,[])/r([],Y).
```

A PROLOG PROGRAM FOR THE 'S-P PROBLEM'

by *António Porto*

Departamento de Informática
Universidade Nova de Lisboa
1899 LISBOA Codex

Reading through issue 37 of AISB Quarterly my attention was drawn to the 'S-P problem', which I had already seen stated in the well-known Martin Gardner's section on Mathematical Games in Scientific American. This time, however, there was along with the problem a challenge, attributed to John McCarthy, to write an 'AI-flavoured' program that could solve it.

The problem follows:

There are two numbers, M and N, such that $1 < M < N < 100$. Mister S is told the sum of the two numbers, Mister P is told their product, and they both know they were told so. The following dialogue takes place:

Mr. P : I don't know the numbers.

Mr. S : I knew you didn't know them;
I don't know them either.

Mr. P : Now I know the numbers!

Mr. S : Now I know them too!

What are the numbers?

That issue of AISB Quarterly also contained what was then considered to be the best reply, so far, to the challenge: it was a Prolog (what else?) program written by Martin Nilsson and John Campbell from the University of Exeter.

I decided to write my own Prolog program for this proplem. It has (I hope) a very clear reading, and uses as building blocks for the formulation of the 'S-P problem' the general subproblems of finding if a given problem has one and only one solution, if it has more than one solution, and if every one of its solutions entails a solution to another problem; these subproblems are efficiently defined.

We can imagine many different problems of the same kind, just by changing the dialogue. Corresponding programs, using my approach, would only differ in the top-level formulation of each particular problem, which just reflects the dialogue taking place.

The whole program, as written for the DEC-10 Prolog compiler, is now presented: (by the way, the solution is M=4 and N=13.)

```
/*      DEFINITION OF INFIX OPERATORS       */

:- op(800,xfy,[one_and_only_one, allows, verifying, every]).
:- op(800,xfy,[implies, more_than_one, have].
:- op(750,xf,:).
:- op(700,xfx,given).

/*      COMPILER DIRECTIVES       */

:- public sp/2, one_and_only_one/2, verifying/2,
          every/2, more_than_one/2, given/2.

:- mode sp(-,-),one_and_only_one(+,+),verifying(+,+),more_than_one(+,+),
        every(+,+),no_record(+),update_record(+),not(+),the_sum_is(-),
        given(+,+),have(+,+),integer(-,+,+),factor(+,+,-).

/*      THE PROBLEM       */

sp(M,N)  :-  the_sum_is(S),
             sentence4 :
             one_and_only_one product(P) given sum(S)
             allows sentence3 verifying Sx=S :
                    one_and_only_one sum(S×) given product(P)
                    allows sentence2 :
                         every product(P×) given sum(S×)
                         implies sentence1 :
                              more_than_one sum(_) given product(P×),
               the_numbers(M,N) have sum_and_product(S,P).

/*      The following subproblems make use of the DEC-10 Prolog        */
/*      recording mechanism, which works as follows:                    */
/*         'recorda(K,T,R)' records term T under key K,                 */
/*                          using reference R.                          */
/*         'recorded(K,T,R)' accesses term T recorded under key K,      */
/*                           its reference being R.                     */
/*         'erase(R)' erases the term recorded with reference R.        */

S : one_and_only_one X allows Y :— call((X,Y)),( recorded(S,_,R),
                                                   erase(R), !,fail ;
                                                 recorda(S,X allows Y,_),
                                                   fail ) ;
                                     recorded(S,X allows Y,R), erase(R).

S verifying P : one_and_only_one X allows Y :—
                         call((X,Y)),( not(P),
                                         no_record(S), !,fail ;
                                       recorded(S,_,R),
                                         erase(R), !,fail ;
                                       recorda(S,X allows Y,_),
                                         fail ) ;
                         recorded(S,X allows Y,R), erase(R).

S : more_than_one X :— call(X),( recorded(S,_,R), erase(R), ! ;
                                   recorda(S,1,_), fail ) ;
                        recorded(S,_,R), erase(R), fail.

S : every X implies Y :— call(X),( not(Y),
                                      no_record(S), !,fail ;
                                    update_record(S), fail ) ;
                          recorded(S,N,R),erase(R),N=2.

no_record(S) :— recorded(S,_,R), erase(R) ;
                true.

update_record(S) :— ( recorded(S,2,_) ;
                      recorded(S,1,R), erase(R), recorda(S,2,_) ;
                      recorda(S,1,_) ), !.

not(X) :— call(X), !,fail ;
          true.

the_sum_is(S) :— integer(S,4,198).

the_numbers(M,N) have sum_and_product(S,P) :— integer(M,2,99),
                                               N is S-M,
                                               P is M*N, !.

product(P) given sum(S) :— S2 is S/2, integer(M,2,S2), P is M*(S-M).

sum(S) given product(P) :— factor(P,2,M), S is M+(P/M).

integer(I,I,_).

integer(I,Low,Up) :— New_low is Low+1, New_low =< Up,
                     integer(I,New_low,Up).

factor(P,M,M) :— O is P mod M.

factor(P,Guess,M) :— New_guess is Guess+1, P >= New_guess*New_guess,
                     factor(P,New_guess,M).
```

LOGIC PROGRAMMING WORKSHOP USA

A Logic Programming Workshop was recently organized by Syracuse University, from 8-10 April, and held at Thornfield, an amenable location on lake Cazenovia, 30 mînutes from Syracuse.

Most of the 60 odd people or so attending were americans and canadians, plus a sprinkle of european "veterans". Logic programming, mainly through the use of Prolog, is picking up speed in the States, and is also very much à la mode.

There were 5, 20 and 30 minute informal presentations, grouped into sections. These were Program Design, Control (compile and runtime), Metalanguage, Data Bases, Implementation, Parallelism, Natural Language, and a General Section (applications, extensions, etc.).

Participation was lively, the surroundings beantiful, and the atmosphere friendly.

MICRO-PROLOG 2.O

Micro-Prolog is an interpreter for a subset of Prolog for micro-computers. Its runs on the Z80 processor, under CP/M operating system, in 32 K bytes of memory. The interpreter itself is 8.5 K bytes (written in Z80 assembler). Speed is approximately 120 resolutions/sec on a 2 MHg Z80 with no wait states. It is available on North Star, Heath/Zenith and 8" formats. Licence for single user, single site is US$250, but multi-user single site agreements are available. For further information contact:

Logic Programming Associates Ltd.
36 GORST RD.
LONDON SW11 6JE

NEWS FROM IMPERIAL COLLEGE

Education. Dr. Kowalski is holder of a three year grant from the Science Research Council to develop "Logic as a computer language for children". Employed on this grant are Frank McCabe, programmer; Richard Ennals, teacher; Diana Reeve, secretary. Using an implementation of Prolog for a micro-computer, "micro-Prolog", written by Frank McCabe, Richard Ennals is writing and using teaching materials. The initial school used in the project is Park House Middle School, in Windkdar, where Robert Kowalski had briefly used some trial materials two years ago. A class of 10-11 yearolds have lessons on two afternoons each week. Copies of the first term's teaching materials are now available. Judging response to date from teachers, teacher-trainers, government inspectors, publishers and local authority education departments, the educational potential of logic programming is considerable "micro-Prolog" currently is implemented for Z80 microprocessors, using the CP/M operating system. It is running on North Star Horizon, Research Machines 3802 and Heathkit Zenit disk-based systems. It is hoped that an effective means of distributing materials, either through government agency or educational publishers, will soon be formulated, with software handled, as at present, through Logic Programming Associates.

Language definition. Chris Moss is just finishing a Ph. D. thesis on the definition of programming languages. Logic is providing a unified approach to both syntax and semantics. Metamorphosis grammars (also called definite clause grammars) allow one to describe the context sensitive portions of a programming language with unrivalled clarity. The dual semantics of Prolog provides a "denotational" and an operational semantics for programs, and they can also express the axiomatic approach.

Program transformation. The work on transformation of algorithms is continuing and the classification of algorithms via synthesis has been extended by Keith Clark, Derek Brough and Phil Vasey.

Loop trapping. The previons investigations by Derek Brough into loop trapping for logic programs has been applied to micro-Prolog to simplify its use in the schools project.

"LOGIC PROGRAMMING CONFERENCE"

The next Logic Programming event will take place at Luminy, an altogether beautiful campus just outside Marseille, France, in the middle of September 1982. The exact date and arrangements are not yet known, but it is to be a major event for the logic programming community.

"HOW TO SOLVE IT WITH PROLOG"

Copies of the August 80 2nd edition of this compilation of Prolog programs may be obtained by writing to:

Hélder Coelho
Laboratório Nacional de Engenharia Civil
Av. do Brasil
1799 Lisboa Codex

"PROLOG BIBLIOGRAPHY"

An updated listing of publications on Prolog may also be obtained from Hélder Coelho, at the address above.

RESEARCH GRANTS AT MARYLAND

Professor Jack Minker informed us that he holds two grants that may be of interest:

(a) Investigations of a predicate logic language for problem solving (NASA).
(b) Investigations of the use of predicate logic in deductive database systems (NSF).

WORK IN PROGRESS AT THE K. U. LEUVEN/ /BELGIUM

In 1979, we have developed a portable Prolog interpreter written in Pascal (space efficient, i.e. tail recursion optimisation).

Last year, we have developed a new interpreter in the language C for the UNIX operating system. In this new interpreter, all names of constants are placed on a file, this results in more working space, but also in some overhead for input/output. Recently, we have connected this interpreter to a simple relational database. When the interpreter accesses this database, it asks for all tuples matching a certain pattern, it pushes all these tuples on a stack. Then it consumes these tuples one by one (the normal backtracking mechanism).

For more information, write to

Maurice BRUYNOOGHE
K. U. LEUVEN
Afdeling Toegepaste Wiskunde
en Programmatie
Celestijnenlaan 200 B
B-3030 Heverlee/Belgium

Report on VLBD Montreal, 1-3 October 1980

by *Robert Kowalski*

Imperial College, London

I was invited to VLDB to participate in a panel on the relationship between database theory and practice. Predictably, my contribution concentrated on the role that logic programming can play in the database field. The reception to my talk was encouraging as was the general attitude towards logic and databases. I got the impression that the database research community has had enough of relational database theory (though not with implementation) and is now ready to look further afield in such directions as logic and artificial intelligence.

A separate panel was organised to report on a workshop held in Colorado earlier this year specifically to explore relationships between databases, abstract data strctures and artificial intelligence. There were several papers presented at the VLDB conference which used logic for query optimisation and integrity checking. I think there will be a lot more activity using logic in these two areas.

The next VLDB will be held in Cannes from 9-11 September 1981. The call for papers explicity included the following topics:

Database and Logic
Natural Languages
Artificial Intelligence
Programming Language and Databases
Knowledge Based Systems

The deadline for submission of papers was 1 March 1981.

IIUW-Prolog

Feliks Kluźniak
Institute of Informatics
Warsaw University
P.O.B. 1210
00-901 Warszawa, Poland

IIUW-Prolog is a Prolog interpreter written in 1979 at the Institute of Informatics, Warsaw University. The program is written entirely in standard Pascal and the language it supports is very similar to a Marseilles version described in Ph.Roussel's 1975 manual.

While the data structures were designed from the scratch to take full advantage of Pascal's type-definition and data-packing features, their basic philosophy is also that of Battani's and Meloni's 1973 Marseilles interpreter. Note, however, that no bootstrapping is employed (*) — the resulting program-reading speed, accompanied by exhaustive diagnostics, makes IIUW-prolog especially suitable for novice Prolog programmers.

The interpreter performs particularly well on the CDC 6000 series computers, thanks to the quality of the ETH Pascal compiler and its ability to get the most out of data-structure packing. We measured the cost — in CPU time — of solving standard Warplan problems on a CYBER 73: the results were comparable to those published by Warren for the Marseilles interpreter on an IBM 360/67. In this test the cost of data packing offsets the difference in processor speed, but better memory utilisation makes it worthwhile. We have always found 72000 (octal) words satisfactory for large programs, and most student jobs can run within the standard limits set for Fortran "quickies". Thus, the performance of IIUW-Prolog seems significantly better than that of the standard Lisp interpreter for this range of machines.

The implementation techniques used in IIUW-Prolog are slightly obsolete, but it was not our aim to advance the state of the art. All we needed was a cheap but reasonably efficient interpreter which we could use to teach Prolog in an academic community that is rather hard-pressed for computer time. The cost of the whole effort, from the initial design to an almost bug-free version, was very low indeed. The present author did it single-handedly in two months, of which a week was spent punching cards and three weeks were used for debugging on a batch system with 3-4 runs a day. (I admit, through, that I put a lot of overtime and did not write the documentation).

After using the interpreter for one year we found it worth-while to add a number of new standard procedures (i.e. evaluable predicates), tracing facilities on so on. By mid-'81 this effort will be over and IIUW-Prolog will probably take over as the standard big-machine implementation in Poland. We will also gladly supply it to anyone who will be interested enough to send us a tape.

(*) While metamorohosis grammars are processed by brute force, the problem of Prolog's variable syntax was rather satisfactorily solved by applying the well-known (though rarely used) algorithm originally designed for the translation of expressions to Reverse Polish notation.

THE PROLOG TEAM AT WARSAW UNIVERSITY

Prolog is not yet widely known in Poland, though research workers at several universities have shown interest in the language, and some are even using it. Our group at Warsaw University, however, is still the only one that is actively concerned with logic programming as such. The group now consists of a core of three persons (Janusz S. Bień, Ph. D., Feliks Kluźniak, M. Sc., Stanislaw Szpakowicz, Ph. D.) and a few cooperating students and programmers. We are mainly interested in implementing Prolog, teaching Prolog and Prolog applications, especially in the field of computational linguistics. Our activities in these three areas are summarized below.

There are at present two Prolog implementations being used in Poland. The first, officially distributed one is a variation of the original Marseilles interpreter; it was cleaned out and extended (eg. by adding tracing facilities), and adapted for the ICL 1900-compatible Polish ODRA 1305 computer. The other version is a new interpreter written in Pascal for the CDC CYBER (see a note on IIUW-Prolog in this newsletter). We are now in the process of porting it to an R-32 (the local version of an IBM 360).

Other implementation efforts are under way. One of these is a Warren-like compiler for the CDC CYBER, which is being written by M. Laziński for his M. Sc. degree.

A regular Prolog course is being taught to computer science students since 1979 (we presented at the Debrecen Workshop a short report on our teaching method). We also do our best to spread knowledge of Prolog outside Warsaw University; an important result in this field is a textbook on Prolog for professional programmers, research workers in computer science and students. The textbook has now been submitted to a Warsaw publisher (Wydawnictwa Naukowo-Techniczne).

Two rather large application programs are worth mentioning. One is a surface-syntactic analyser of written Polish (by Szpakowicz); the other is an experimental interactive railway timetable information system with natural language interface (by Szpakowicz and Marek Świdziński).

Warsaw, Jan. 1981.

Stanisław Szpakowicz

FORTHCOMING BOOKS

"Programming in Prolog", by William F. Clocksin and Christopher S. Mellish, from the Dept. of Artificial Intelligence at Edinburgh, is the long waited for primer on Prolog, by experienced practicioneers. It is to be published by Edinburgh University Press this year. Here are some extracts from its Preface:

Until now, there has been no textbook with the aim of teaching Prolog as a practical programming language. It is perhaps a tribute to Prolog that so many people have been motivated to learn it by referring to the necessarily concise reference manuals, a few published papers, and by the orally transmitted 'folklore' of the modern computing community. However, as Prolog is beginning to be introduced to large numbers of undergraduate and postgraduate students, many of our colleagues have expressed a great need for a tutorial guide to learning Prolog. We hope this little book will go some way towards meeting this need.

This book can serve several purposes. The aim of this book is not *to teach the art of programming as such. We feel that programming cannot be learned simply by reading a book or by listening to a lecturer. You've got to* do *programming to learn it. We hope that beginners without a mathematical background can learn Prolog from his book, although in this case we would recommend that the beginner is taught by a programmer who knows Prolog, as part of a course that introduces the student to programming as such. It is assumed that the beginner can obtain the use of a computer that has a Prolog system installed, and that he has been instructed in the use of a computer terminal. The experienced programmer should not require extra assistance, but he also should not dismay at our efforts to restrain mathematical affectation.*

Like most other programming languages, Prolog exists in a number of different implementations, each with its own semantic and syntactic peculiarities. In this book we have adopted a "core Prolog", and all of our examples conform to a standard version that corresponds to the implementations, developed mainly at Edinburgh, for three different computer systems: the DECsystem-10 running TOPS-10, the DEC PDP-11 running Unix, and the PDP-11 running RT-11. These implementations are probably the most widespread. All the examples in this book will run on all three of the implementations. In an appendix, we list some of the existing Prolog implementations, indicating how they diverge from the standard.. The reader will appreciate that most of the deviations are of a purely cosmetic nature.

This book was designed to be read sequentially. Each chapter is divided into several sections, and we advise the reader to attempt the exercises that are at the end of most sections. The solutions to many of the exercises appear at the end of the book. Chapter 1 is a tutorial introduction that is intended to give the reader a "feel" for what is required to program in Prolog. The fundamental ideas of Prolog are introduced, and the reader is advised to study them carefully. Chapter 2 presents a more complete discussion of points that are introduced in Chapter 1. Chapter 3 deals with data stuctures and derives some small example programs. Chapter 4 treats the subject of backtracking in more detail, and introduces the "cut" symbol, which is used to control backtracking. Chapter 5 introduces the facilities that are available for input and output. Chapter 6 describes each built-in predicate in the standard "core" of Prolog. Chapter 7 is a potpourri of example programs collected from many sources, together with an explanation of how they are written. Chapter 8 offers some advice of debugging Prolog programs, and provides an alternative model of control flow. Chapter 9 introduces the Grammar Rule syntax, and examines the design decisions for some aspects of analysing natural language by using Grammar Rules. Chapter 10 describes the relation of Prolog to its origins in mathematical theorem proving and logic programming. Chapter 11 specifies a number of projects on which interested readers may wish to practise their programming ability.

"LOGIC PROGRAMMING WORKSHOP 1"

A book coming out of the workshop held last July at Debrecen, Hungary, is being edited by Keith Clark and Sten-Ålke Tarnlünd. The book contains re-written versions of many of the papers presented at Debrecen, as well as some entirely new contributions. All were refereed by the present Logic Programming Workshop 2 Comittee.

"MATHEMATICAL LOGIC PROGRAMMING COLLOQUIUM 78"

The proceedings of this Colloquium, held at Salgotarjan, Hungary, in September 1978, are now under print by North-Holland, and should be out before next summer.

abstracts

NEW PAPERS

from Syracuse:

Programming with Full First Order Logic

Kenneth A. Bowen

An automatic deduction system based on a modification of Gentzen's sequentzen system LJ is presented and its use as the basis for a logic programming system is described. The system is a natural extension of Horn clause logic programming systems in that when all of the formulas in the input sequent are atomic, the behavior of the system mimics that of LUSH resolution systems. The use of such systems in program development systems and in database management systems is discussed.

Loglisp — An Alternative to Prolog

J. A. Robinson
E. E. Sibert

(No abstract provided)

Logic Programming in Lisp

J. A. Robinson
E. E. Sibert

This document describes version V1M1 of LOGLISP, an extension of LISP in which one can do logic programming [Kowalski 1974, 1979]. The logic programming system within LOGLISP is called LOGIC. Thus we have: LOGLISP = LOGIC + LISP.

LOGIC differs in a number of ways from the well-known PROLOG implementations of logic programming [Roussel 1975], [Warren 1977], [Roberts 1977], [Clark 1979]. The most noteworthy difference is that LOGIC is simply a set of new LISP primitives designed to be used freely within LISP programs. These primitives are invoked in the ordinary LISP manner by function calls from the terminal or from within other LISP programs. They return their results as LISP data objects which can be subjected to analysis and manipulation. Each of the logical procedures comprising a LOGIC knowledge base is a LISP data objet kept (like the definition of an ordinary LISP procedure) on the property list of the identifier which is its name.

Thus one calls LOGIC from within LISP. It is also possible to call LISP from within LOGIC. The identifiers used as logical predicate symbols, function symbols and individual constants within a knowledge base or query can ben given a LISP meaning by the ordinary LISP method of definition or assignment. Some identifiers (CAR, CONS, PLUS, etc.) already have a LISP meaning imposed by the system. Thus every logic construct (term, or atomic sentence) is capable of being interpreted as a LISP construct. During the deduction cycle of LOGIC each logic construct is "evaluated" as a LISP construct, according to a suitably generalized notion of evaluation.

The effect of this LISP-simplification step within each deduction step is to make available to the LOGIC programmer virtually the full power of LISP. This makes trivially easy the "building-in" of "immediately evaluable" notions — but far more than that. In particular, LOGIC calls can be made from within LOGIC calls.

from Waterloo:

Predicate Logic as a Language for Parallel Programming

by *M. H. van Emden, G. J. de Lucena* *
& *H. de M. Silva*

We describe the formulation, execution, semanticization, and verification within first--order predicate logic of programs in Kahn's model of computation. The relations computed by process activations are defined in logic. The state of a network of communicating parallel processes is specified in a single statement of logic which is a concise textual representation of such a network. The state is understood to comprise the configuration of the network of process activations, the contents of the channels, as well as the state of each sequential computation within a process activation.

It is possible to derive within logic results from the process definitions and from the state specification in such a way that each stage of the derivation can again be interpreted as a state of a parallel computation and that the transitions between stages is also directly meaningful in terms of Kahn's model of computation.

We show that dataflow programs in Lucid are closely related to our representation of these programs in logic. We give an example of partial verification of a terminating program. Finally, we sketch the application of recent results on greatest fixpoints and infinitary Herbrand universes to verification of nonterminating programs.

from Maryland:

On Optimizing the Evaluation of a Set of Expressions

John Grant and *Jack Minker*

A branch-and-bound type algorithm is developed to optimize the evaluation of a set of expressions. This algorithm proceeds in a depth-first manner and achieves an optimal solution. The algorithm is applied to optimize the evaluation of sets of relational expressions. Analogies to the heuristic information associated with the A*-algorithm are investigated. Examples are presented illustrating the use of the algorithm. Pragmatics associated with the algorithm are discussed. Using the same framework, we present a new method to optimize the evaluation of Boolean expressions.

Optimization in Deductive and Conventional Relational Database Systems

John Grant and *Jack Minker*

A deductive relational database system is one which permits new relations to be derived from given relations stored in a conventional relational database system, and from axioms. It has been shown that a query in a deductive relational database system can be transformed, using the axioms, into a query that involves searches only over the relational database. The transformed query results in a set of conjuncts which generally share similar if not identical searches that must be made of the indexes and the tables storing the relations. The purpose of this paper is to describe a "global" optimizing algorithm which accounts for similarities between conjuncts.

The algorithm consists of two major parts: the preprocessor and the optimizer. The preprocessor is used once for a given set of axioms and indexes. Its functions are to: transform each atomic query type into a group of formulae, list al possible access methods for single tables and join-supported joins and to calculate costs for the access methods. The optimizer is used to select a method of evaluation of the formulae which answers the query in the shortest possible time. Details concerning the preprocessor and the optimizer are provided. An example is given that shows the effectiveness of "global" optimization in contrast to optimizing the retrieval of individual conjuncts. The changes needed to incorporate semantic knowledge into the algorithm are also given.

A Set-Oriented Predicate Logic Programming Language

Jack Minker

A predicate logic language based on types and set operations is presented. The use of set operations is shown to alleviate some problems associated with backtracking in nondeterministic systems.

The basic syntax and semantics of the typed-set-oriented language is specified. It is shown that types and set operations may be embedded as part of the unification algorithm. This permits a uniform way to handle types and set operations, and permits dynamic type checking.

The inference mechanism and bookkeeping features employed with the system provide debugging features for the user. A discussion of some of the features in the language is presented. We discuss both the limitations of some of the features, and how a number of features described may be incorporated within a language such as PROLOG by modification to the control structure.

from Pisa:

Using Meta-Theoretic Reasoning to do Algebra

by *L. Aiello* and *R. W. Weyhrauch*

We report on an experiment in interactive reasoning with FOL. The subject of the reasoning is elementary algebra. The main point of the paper is to show how the use of meta-theoretic knowledge results in improving the quality of the resulting proofs in that in this environment they are both easier to find and easier to understand.

Evaluating Functions Defined in First Order Logic

by *L. Aiello*

After a short introduction to FOL, an interactive reasoning system for first order logic, we present a way of extending the use of the FOL evaluator by showing how systems of (mutually recursive) function definitions formulated in first order logic can be translated into programs. This allows function definitions (syntactic objects) to be treated as programs (semantic objects). The advantages of this translation are illustrated.

The Call-by-Name Semantics of a Clause Language with Functions

by *M. Bellia, P. Degano* and *G. Levi*

The paper presents a language which extends TEL, a functional language, with (somewhat constrained) Horn clauses. The resulting language provides some features which are characteristic of relational languages, such as procedures with more than one output. We have defined an operational semantics, based on a lazy evaluation rule. Finally, a call-by-name semantics is given, which is an extension of the tarskian model theoretical semantics.

From term Rewriting Systems to Distributed Programs Specifications

by *M. Bellia, E. Dameri, P. Degano, G. Levi, M. Martelli*

The paper presents a formal model for distributed systems of computing agents, which is based on extended term rewriting systems. An operational semantics is given, which neatly mirrors both the non-deterministic and the parallel features of systems of computing agents. The formalism we introduce has an immediate interpretation in terms of first order logic. Thus, we provide it with a fixed-point semantics, closely related to the model theoretic semantics of first order theories.

from Marseille:

Dialogues en Français avec un Ordinateur

Paul Sabatier
(now at Universidade Nova de Lisboa)

We present a complete system of natural language communication with a computer, in which a casual user can describe and modify an open world dealing with persons and objects (any proper noun). Persons give, lend, exchange objects they possess and/or they hold. The user can ask any question about the current relations of possession between the different persons and objects. Written in PROLOG, this system provides a logic for actions, questions, presuppositions and ellipsis sentences.

PROLOG: A Language for Implementing Expert Systems

K. L. Clark, F. G. McCabe
Dept. of Computing
imperial College, London SW7 ZBZ
November 1980

ABSTRACT

We briefly describe the logic programming language PROLOG concentrating on those aspects of the language that make it suitable for implementing expert systems. We show how features of expert systems such as:

(1) inference generated ed requests for data,
(2) probabilistic reasoning,
(3) explanation of behaviour

can be easily programmed in PROLOG. We illustrate each of these features by showing how a fault finder expert could be programmed in PROLOG.

research centres addresses

Dept. de Informática
Universidade Nova de Lisboa
Quinta do Cabeço
1899 Lisboa Codex Portugal

Dept. of Artificial Intelligence
University of Edinburgh
9 Hope Park Sq.
Edinburgh EH8 9NW UK

Dept. of Computing and Control
Imperial College
180 Queen's Gate
London SW7 2BZ UK

Groupe d'Intelligence Artificielle
Universite d'Aix-Marseille II
70 route Leon Lachamps Case 901
13288 Marseille Cedex 2 France

Afdeling Toegepaste
Wiskunde en Programmatie
Katholieke universiteit Leuven
Celestijnenlaan 200 A
B — 3030 Haverlee Belgie

Dept. of Information Processing
and Computer Science
Stockholms Universitet
S-106 91 Stockholm Sweden

Ist. di Scienze dell' Informazione
Universita di Pisa
Corso Italia 40
I-56100 Pisa Italia

Institut fur Informatik
Universitat Karlsruhe
Postfach 6380
D-7500 Karlsruhe 1 Deutschland

SZKI
P.O.B. 224
Budapest H-1368 Hungary

Institute of Informatics
University of Watsaw
P.O.box 1210
00-901 Warszawa Poland

School of Computer and
Information Science
Syracuse University
Syracuse,
New York 13210 USA

Dept. of Information
and Computer Science
University of California
Irvine,
California 92717 USA

Dep. of Computer Science
University of Waterloo
Waterloo, Ontario Canada