ICOT Technical Memorandum: TM-0826

TM-0826

Guide to the Japanese Demonstrations at France-Japan Artificial Intelligence and Computer Science Symposium '89

by
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Institute for New Generation Computer Technology

Guide to the Japanese Demonstrations

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Institute for New Generation
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Program

Wednesday, 15 November

14:30–16:30 Demonstrations

- Demo Session A (on PSI-II)

14:30–15:00	CAL
15:00–15:30	CAP-LA
15:30–16:00	VISTA
16:00–16:30	Kappa

- Demo Session B (on PSI-II)

14:30–15:00	APRICOT/0
15:00–15:30	MECHANICOT
15:30–16:00	LTB

Thursday, 16 November

13:30–15:30 Demonstrations

- Demo Session A (on PSI-II)

13:30–14:00	CAL
14:00–14:30	CAP-LA
14:30–15:00	VISTA
15:00–15:30	Kappa

- Demo Session B (on PSI-II)

13:30–14:00	APRICOT/0
14:00–14:30	MECHANICOT
14:30–15:00	LTB

A List of Demonstrations

- *Demo Session A (on PSI-II)*

1. *Constraint Logic Programming Experimental System* **CAL**

2. *Computer Aided Proof* **CAP-LA**

3. *Visualization and Transformation Apprentice for Concurrent Logic Programming* **VISTA**

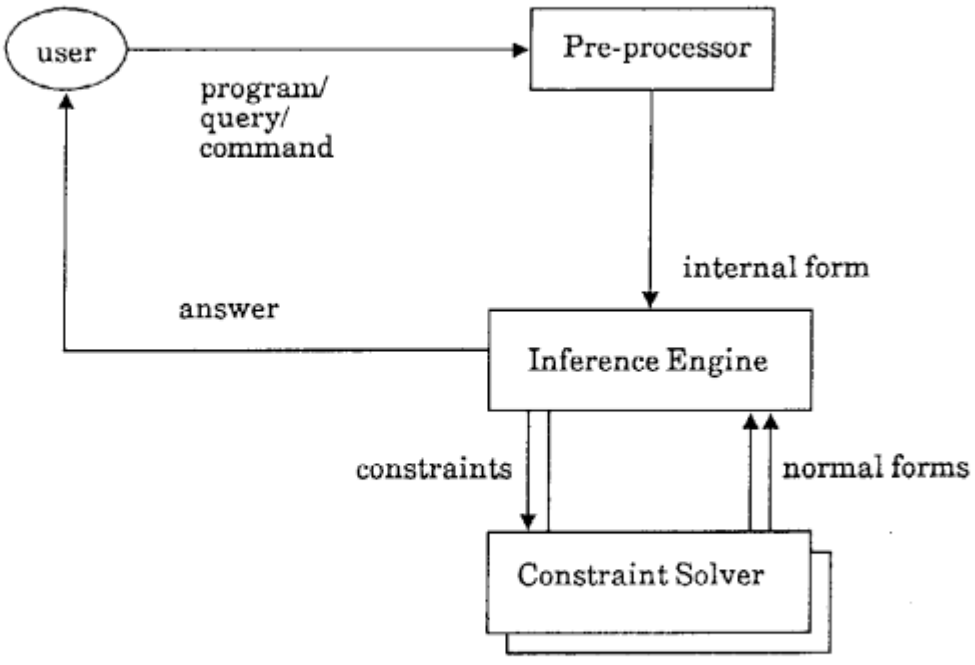
4. *Knowledge Application Oriented Advanced DBMS* **Kappa**

- *Demo Session B (on PSI-II)*

5. *Assumption-Based Problem Solver* **APRICOT/0**

6. *Constraint-Based Knowledge Compiler -Design Expert System Building Tool-* **MECHANICOT**

7. *A Software Library for Japanese Language Processing* **LTB**

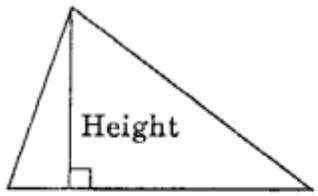
Title	Constraint Logic Programming Experimental System CAL
Purpose	1) Programs easier to write and read 2) Highly abstract programming 3) Research on efficient problem solving techniques
Outline & Features	1) Amalgamation of logic programming and constraint solving 2) Multiple Constraint Solvers 3) Solution of non-linear algebraic equations and Boolean equations 4) Natural extension of Prolog
System Configuration	

★ Examples of CAL : Heron's Formula(non-linear)

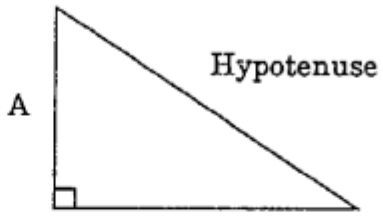
Program & Query&Answer

```
:– public triangle/4, triangle1/4.
surface(Height, Base, Area) :– Base * Height = 2*Area.
pythagoras(A, B, Hypotenuse) :– A^2 + B^2 = Hypotenuse^2.
triangle(A, B, C, S) :–
        C = CA + CB:alg,
        pythagoras(CA, H, A),
        pythagoras(CB, H, B),
        surface(H, C, S).
triangle1(A, B, C, S) :– precedence(S :> 0), triangle(A, B, C, S).

?– heron:triangle1(a, b, c, s).

s^2 =  –1/16*b^4+1/8*a^2*b^2–
       1/16*a^4+1/8*c^2*b^2+1/8*c^2*a^2–1/16*c^4
```

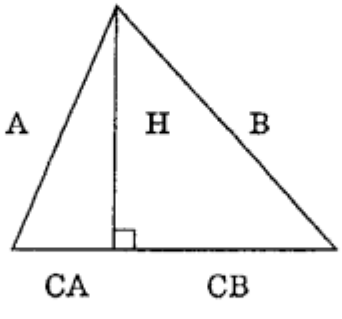
surface:



pythagoras:



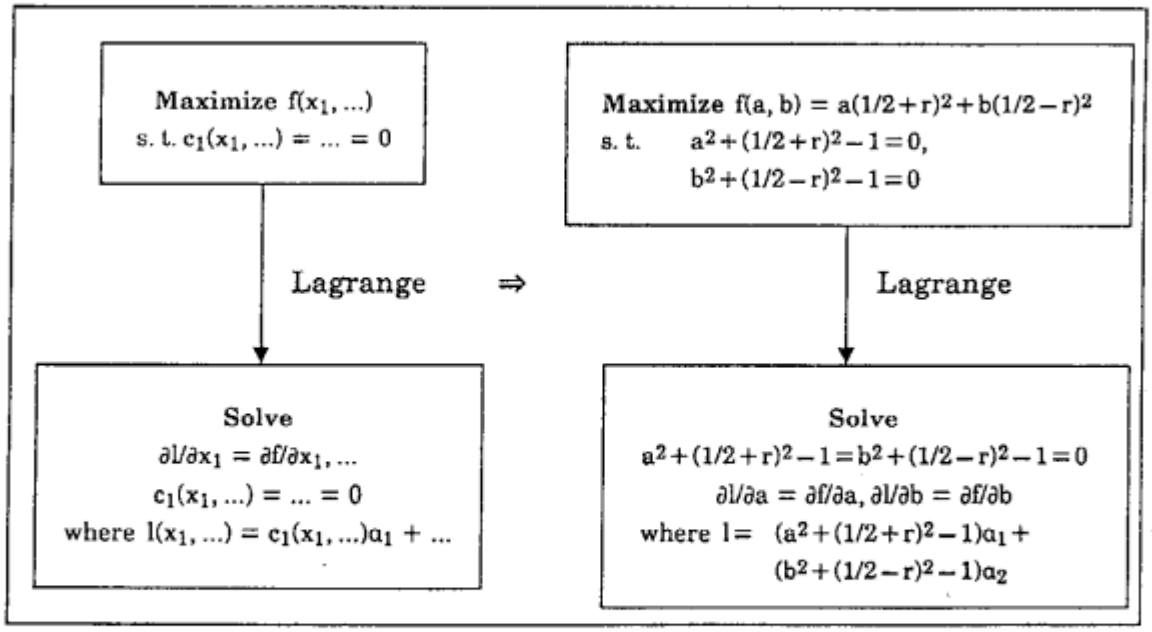
triangle:



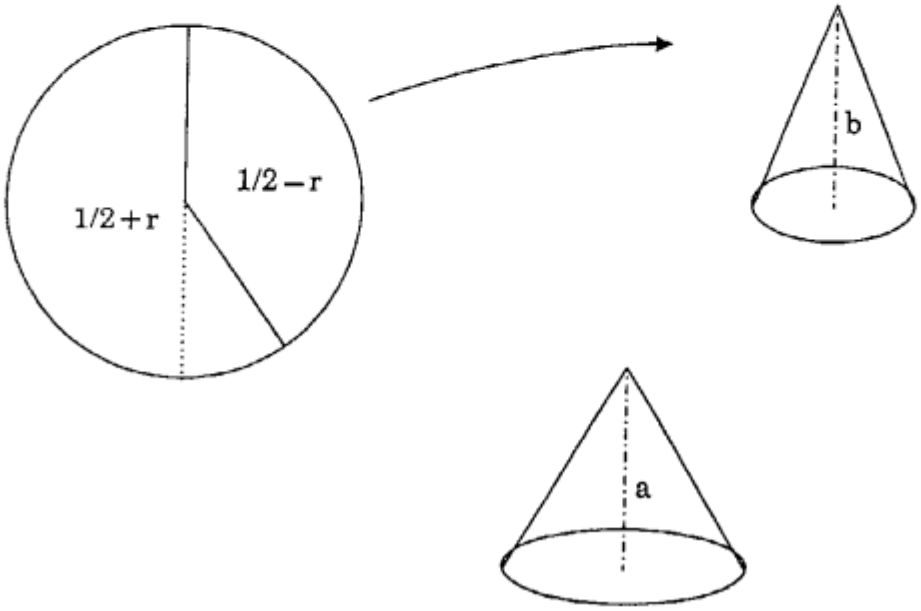
★ Examples of CAL : Cone Volume using Lagrange(dynamic constraints)

Program & Query&Answer

```
:– public lagrange/3.
lagrange(F, Constraints, Vars) :–
        construct__l(Constraints, L),
        partials(Vars, F, L).
partials([ ], __, __) :– !.
partials([Var|Vars], F, L) :–
        dif(F, Var) = dif(L, Var):alg,
        partials(Vars, F, L).
construct__l([ ], 0) :– !.
construct__l([C|Cs], C*Alpha + L) :–
        C = 0:alg,
        construct__l(Cs, L), !.

?– lagrange((1/2+r)^2*a+(1/2–r)^2*b,
                [a^2+(1/2+r)^2 = 1, b^2+(1/2–r)^2 = 1],
                [a, b, r]).

r^7=(29/12)*r^5+(–17/48)*r^3+(5/576)*r
```



D e t a i l s (3/5)



Query

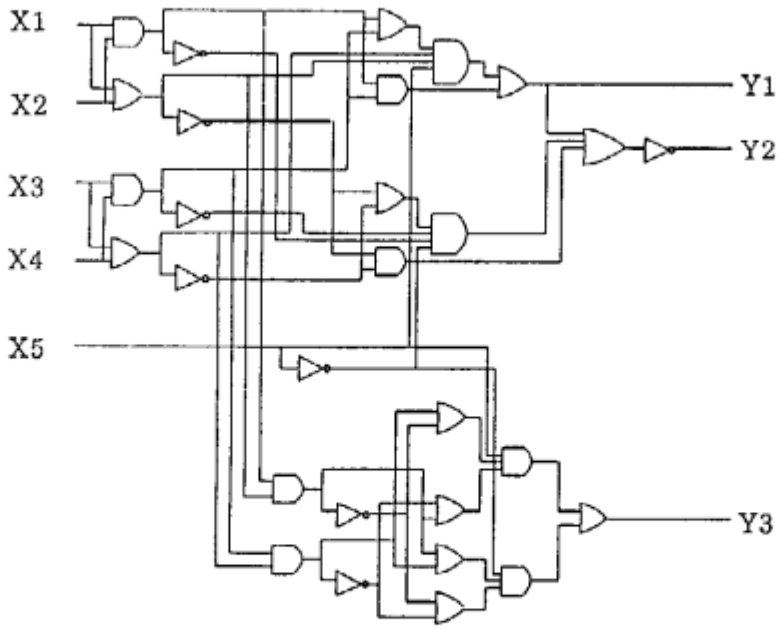
```
?- lagrange((1/2+r)^2*a+(1/2-r)^2*b,
            [a^2+(1/2+r)^2 = 1, b^2+(1/2-r)^2 = 1],
            [a, b, r]).
```

D e t a i l s (4/5)

★ Examples of Boolean CAL : Counter Circuit

Program&Query&Answer

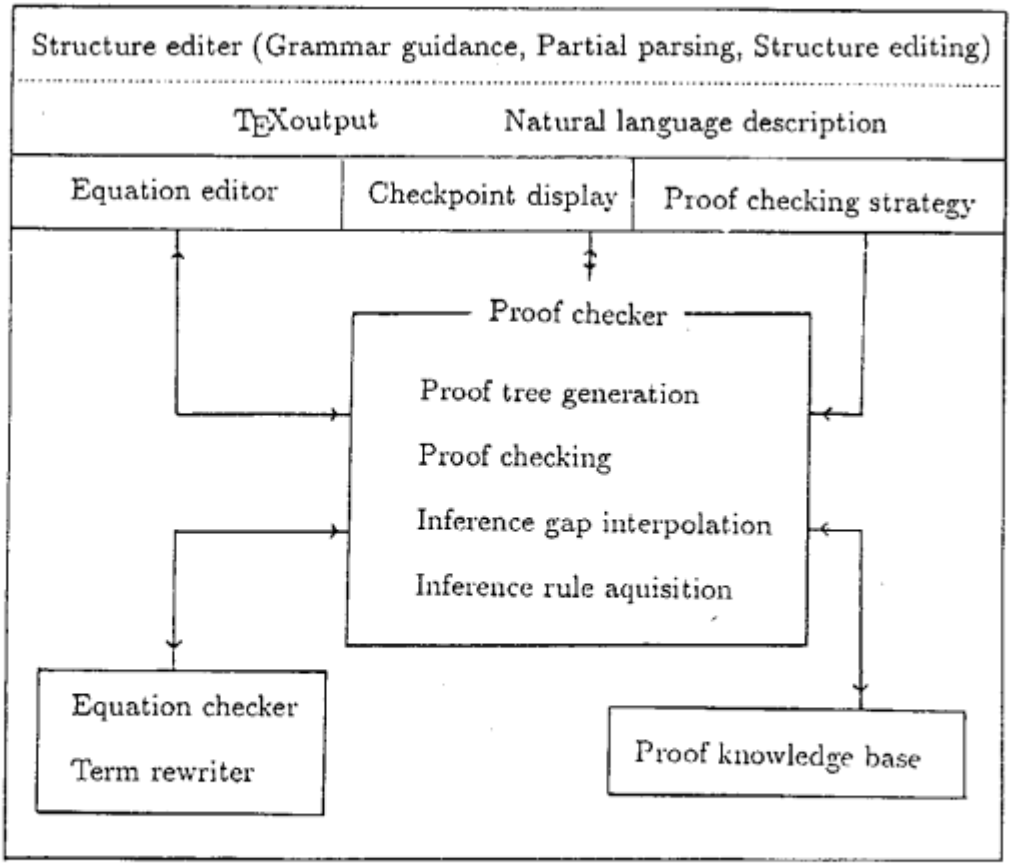
```
:– public circuit/8.
circuit(X1, X2, X3, X4, X5, Y1, Y2, Y3) :–
    I1 = X1&X2:bool,      I2 = X1 V X2:bool,      I3 = X3&X4:bool,
    I4 = X3 V X4:bool,    I5 = I1:bool,           I6 = I2:bool,
    I7 = I3:bool,         I8 = I4:bool,           I9 = I1 V I3:bool,
    I10 = I1&I3:bool,     I11 = I6 V I8:bool,     I12 = I6&I8:bool,
    I13 = X5:bool,        I14 = I5&I2:bool,       I15 = I7&I4:bool,
    I16 = I14:bool,       I17 = I15:bool,         I18 = I15 V I16:bool,
    I19 = I14 V I17:bool, I20 = I14 V I15:bool,   I21 = I16 V I17:bool,
    I22 = I9&I4&I2&X5:bool,   I23 = I11&I7&I5&I13:bool,
    I24 = X5&I18&I19:bool,    I25 = I13&I20&I21:bool,
    I26 = I22 V I10:bool,     I27 = I26 V I23 V I2:bool,
    Y1 = I26:bool,        Y2 = I27:bool.          Y3 = I24 V I25:bool.

?– count:circuit(x1,x2,x3,x4,x5,1,0,1).
?– count:circuit(1,x2,x3,x4,x5,y1,y2,y3), x2 = x3 : bool.x5 = 1.
```



★ Conclusions

- *Constraint Logic Programming*
  1) Constraint Logic Programming extends unification to constraint solving, allowing symbolic answers to queries
  2) Powerful semantically clean, language in which to generate and solve constraints.
  3) More powerful pruning of search space.

- *CAL*
  1) Solves linear and non-linear equalities over complex numbers using Gröbner Base method.
  2) Solves Boolean constraints using Boolean Gröbner Base method developped at ICOT.

Title	Computer Aided Proof (CAP-LA)
Purpose	(1) Man-machine cooperation in mathematical problem solving (2) Assistance in proof checking and formula manipulation
Outline & Features	outline (1) Checking theorems and proofs in linear algebra (2) Assistance in writing therorems and proofs features (1) Checking proofs with inference gaps (2) Interactive checking and debugging (3) Proof-structure-oriented writing and editing
System Configuration	

D e t a i l s (1／3)

Proof written in PDL (Proof Description Language)

```
theorem
  det_trans:
  all A:squ_mat.
    det(A)=det(trans(A))
  proof
    let A:squ_mat be arbitrary;
    row(A)=col(trans(A));
    col(A)=row(trans(A));
    det(A)=sigma p:perm<col(A)>.
              (sgn(p)*pi i:1..col(A).
                        A[p(i), i])
           =sigma p:perm<col(A)>.
              (sgn(inv(p))*pi i:1..col(A).
                        A[(inv(p))(i), i])
            using sigma_pi
           =sigma p:perm<col(A)>.
              (sgn(p)*pi i:1..col(A).
                        A[(inv(p))(i), p(i)])
            using sigma_pi
           =sigma p:perm<col(A)>.
              (sgn(p)*pi i:1..col(A).
                        A[(inv(p))(p(i)), p(i)])
            using sigma_pi
           *sigma p:perm<col(A)>.
              (sgn(p)*pi i:1..col(A).
                        A[i, p(i)])
            using sigma_pi
           =sigma p:perm<col(A)>.
              (sgn(p)*pi i:1..col(A).
                        (trans(A))[p(i), i])
            using sigma_pi
           =det(trans(A))
    end_proof
  end_theorem
```

TEX output

THEOREM: *det_trans:*
For all A ∈square matrix,

$$\det(A) = \det({}^tA)$$

PROOF:
Now let A ∈square matrix be arbitrary.

$$\mathrm{row}(A) = \mathrm{col}({}^tA)$$

$$\mathrm{col}(A) = \mathrm{row}({}^tA)$$

$$\det(A) = \sum_{p \in S_{\mathrm{col}(A)}} \mathrm{sgn}(p) \prod_{i=1}^{\mathrm{col}(A)} A_{p(i),i}$$

$$= \sum_{p \in S_{\mathrm{col}(A)}} \mathrm{sgn}(p^{-1}) \prod_{i=1}^{\mathrm{col}(A)} A_{p^{-1}(i),i}$$

using sigma_pi

$$= \sum_{p \in S_{\mathrm{col}(A)}} \mathrm{sgn}(p) \prod_{i=1}^{\mathrm{col}(A)} A_{p^{-1}(i),p(i)}$$

using sigma_pi

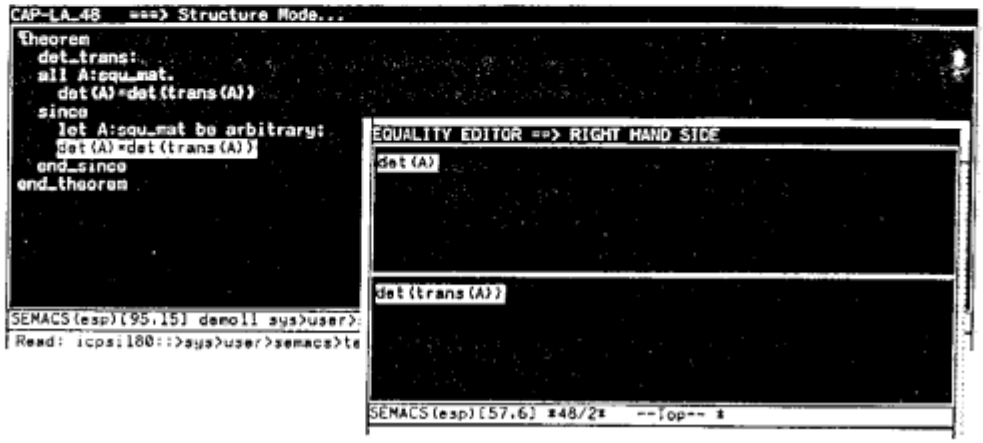
$$= \sum_{p \in S_{\mathrm{col}(A)}} \mathrm{sgn}(p) \prod_{i=1}^{\mathrm{col}(A)} A_{p^{-1}(p(i)),p(i)}$$

using sigma_pi

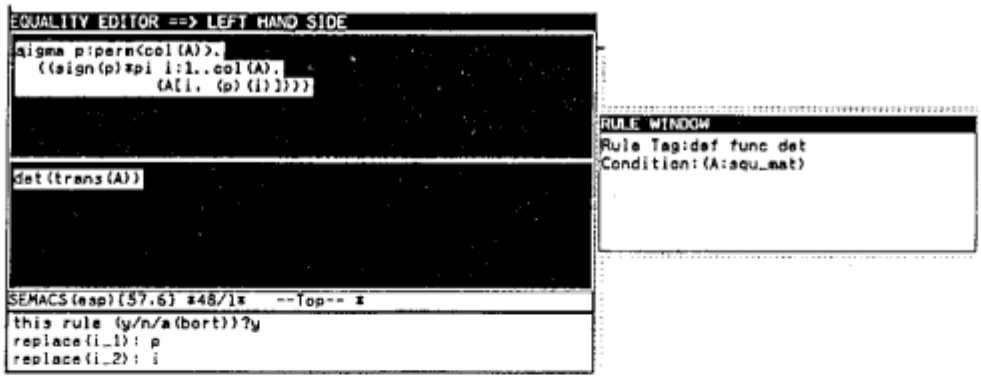
D e t a i l s (2/3)

Equation Editor

(1) Initialization



(2) Formula manipulation



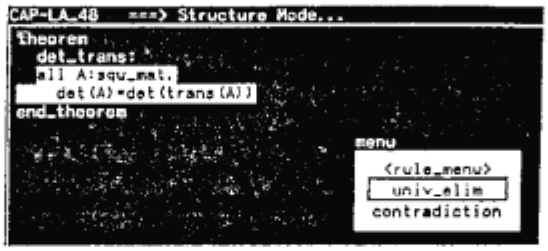
(3) Final result

D e t a i l s (3/3)

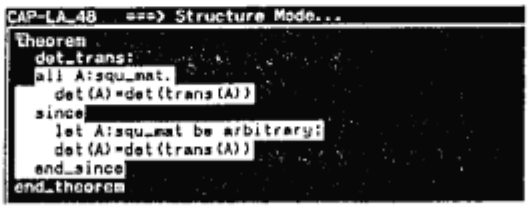
Structure-oriented proof development

(This example illustrates "universal quantifier elimination")

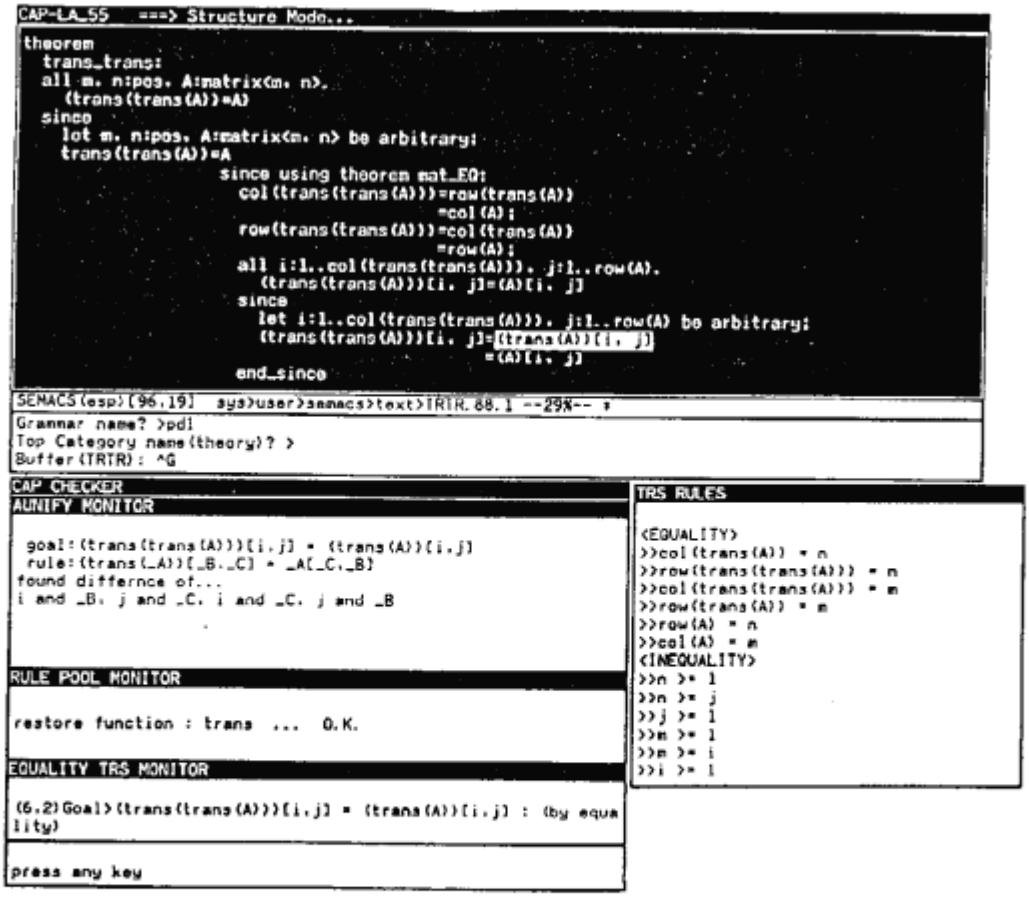
Before elimination

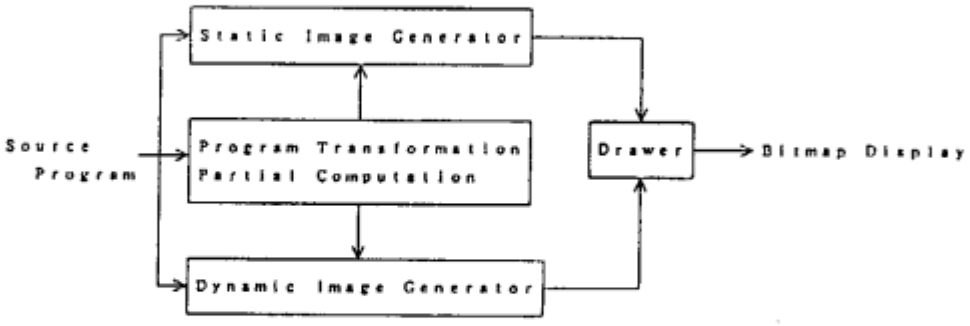


After elimination



Proof checking (This example illustrates an error in indexing)



Title	V I S T A : Visualization and Transformation Apprentice for Concurrent Logic Programming
Purpose	The system helps programmers develop concurrent logic programs easily by providing visualization of program structures which may be useful to understand programs.
Outline & Features	◇ VISTA has two visualization modes - Static mode : a structure of the program is visualized by unfolding a given top level goal. - Dynamic mode : an execution of the program is visualized by replacing a parent process with child processes and by redrawing the stream lines between processes. ◇ VISTA can be used to examine concurrent programming techniques - Layered-stream program - Knuth-Bendix completion program ◇ VISTA can be used to compare different versions of programs - Two versions of unification program - Partially evaluated program and its original
System Configuration	

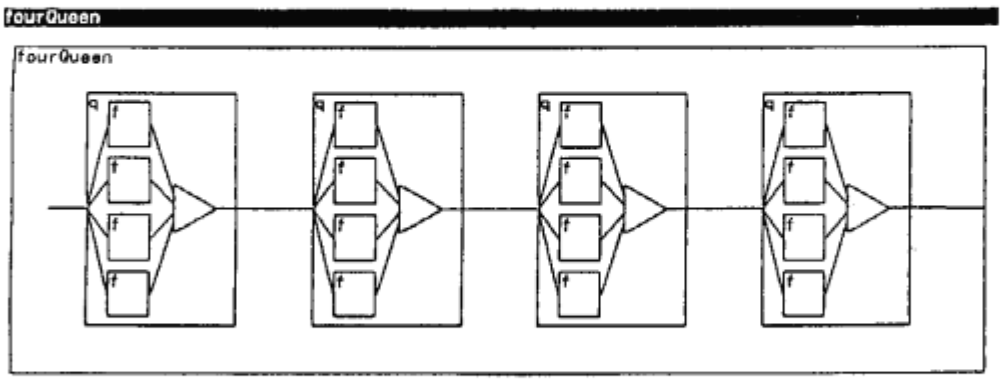
D e t a i l s (1/4)

◇ Layered-stream program

Layered stream is a type of data structure, which is designed for efficient search programming in GHC. Through a layered stream, information is propagated to consumer processes as soon as possible, even if the information is incomplete. Thus it provides very high parallelism. In our demonstration, a 4-Queens program using a Layered Stream is visualized.

Source program:

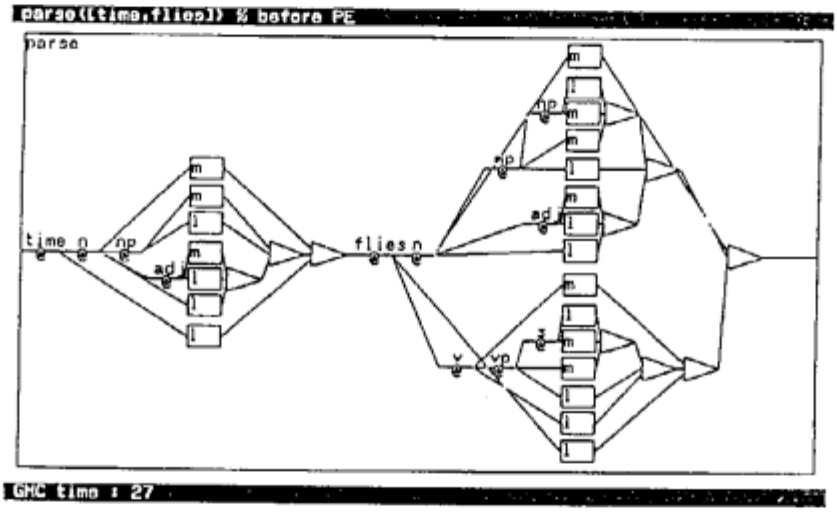
```
fourQueens(Q4) :- true |
        q(begin,Q1), q(Q1,Q2), q(Q2,Q3), q(Q3,Q4).

q(In,Out) :- true |
        filter(In,1,1,Out1), filter(In,2,1,Out2),
        filter(In,3,1,Out3), filter(In,4,1,Out4),
        Out = [1*Out1,2*Out2,3*Out3,4*Out4].

filter(begin,_,_,Out) :- true | Out = begin.
filter([],_,_,Out) :- true    | Out = [].
filter([I*_|Ins],I,D,Out) :- true      | filter(Ins,I,D,Out).
filter([J*_|Ins],I,D,Out) :- D =:= I-J | filter(Ins,I,D,Out).
filter([J*_|Ins],I,D,Out) :- D =:= J-I | filter(Ins,I,D,Out).
filter([J*In1|Ins],I,D,Out) :- J \= I, D =\= I-J, D =\= J-I |
        D1 := D+1, filter(In1,I,D1,Out1),
        filter(Ins,I,D,Outs),
        Out = [J*Out1|Outs].
```

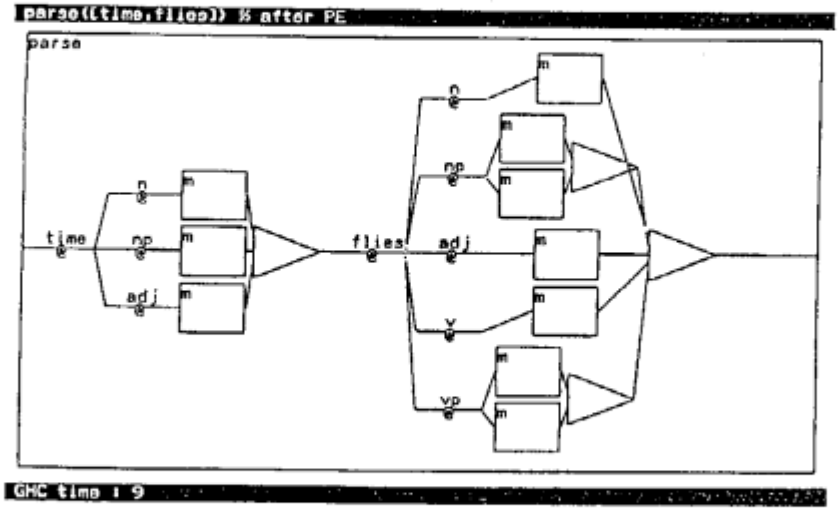


D e t a i l s (2/4)

◇ Parsing program

A parsing program called Meta-PAX is presented. Meta-PAX, given a set of grammar rules and a sentence, checks whether the sentence is acceptable. A sentence varies each time Meta-PAX is used whereas a set of grammar rules is fixed for some time while Meta-PAX is used, for parsing many sentences. Using partial evaluation, a version of the Meta-PAX program specialized for the given set of grammar rules is obtained which is more efficient than the original program.

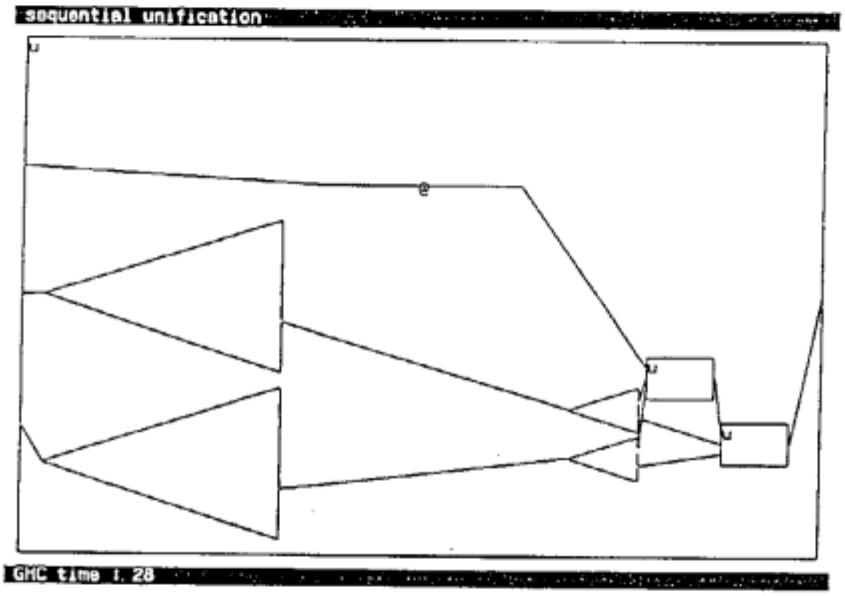


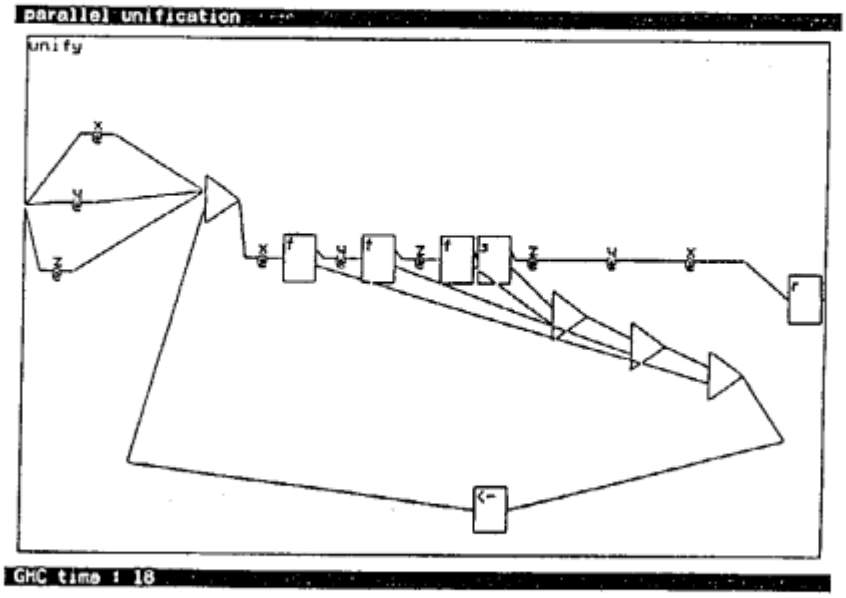


D e t a i l s (3/4)

◇ Unification program

Two programs for unifying two terms are presented. The difference between the programs can be easily seen by visualizing them. The first one tries to unify two compound terms one branch at a time, updating the intermediate result of the unifying substitution. The second one tries to generate a unifying substitution at each branch of the given compound terms in parallel and tries to check consistency between separately generated substitutions.

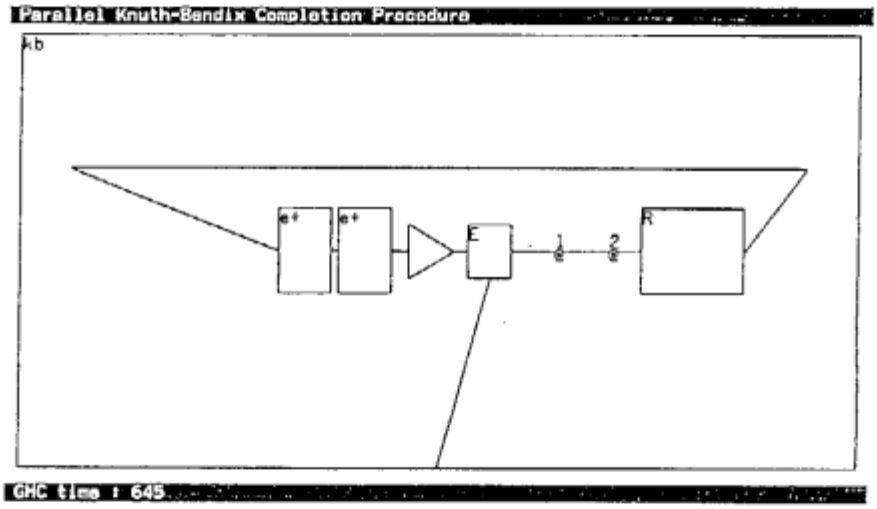


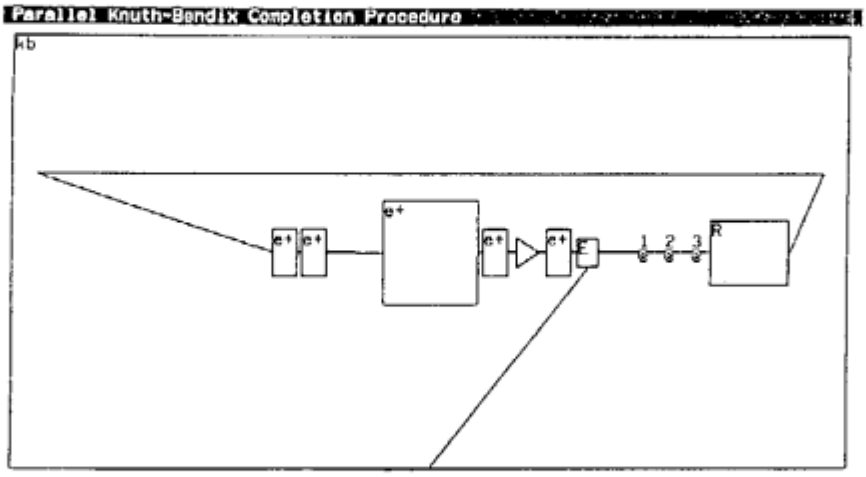


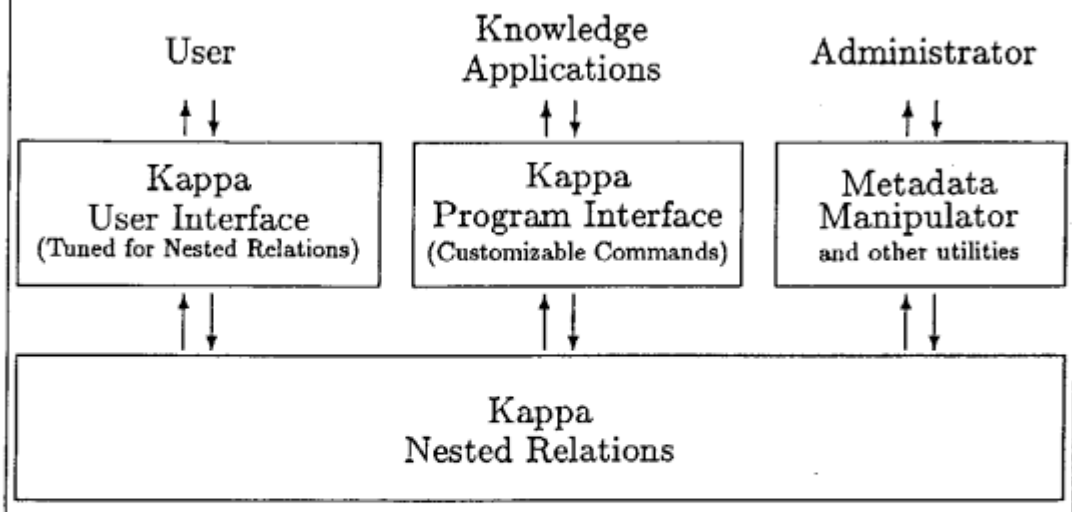
D e t a i l s (4/4)

◇ Knuth-Bendix completion program

The Knuth-Bendix completion program is a kind of a compiler that, given a set of equations, produces a set of term rewriting rules which has a nice property called canonical. There are two major processes running in parallel in the program: one for converting an equation to a rewrite rule, the other for generating a new equation (called a critical pair) from a pair of rewrite rules. Critical pair generation can be done in parallel for every pair of rewriting rules, whereas conversion of an equation has to be serialized so that the simpler rewriting rule is generated first. The serialization of the conversion process is realized by using a unique programming technique that makes the most of stream parallelism.





Title	Knowledge Application Oriented Advanced DBMS : Kappa
Purpose	Kappa, a DBMS based on the nested relational model, is implemented on PSI-II in order to study management of very large and/or complex structured databases in the logic programming environment and to provide a platform for implementing various knowledge applications (including deductive DBs and semantic networks).
Outline & Features	Kappa is a DBMS with the following features: 1. Nested relational model is adopted. 2. Terms stored as one data type are retrieved by unification. 3. Large amounts of data, such as electronic dictionaries, mathematical knowledge and genetic information, are effectively accessed. 4. An User interface suitable for nested relations and program interface customizable for various applications are provided. 5. It's written in object-oriented logic programming language ESP, and will be rewritten in parallel language KL1.
System Configuration	

GenBank Sequence DB on Kappa

1 Guidance

1.1 Features of Nested Relational Model

The definition of the nested relational model (according to the standpoint of Kappa) is:

$$NR \subseteq E_1 \times \ldots \times E_n$$

$$E_i ::= D \mid 2^{NR}$$

while that of the relational model is:

$$R \subseteq D_1 \times \ldots \times D_n$$

where D_i is a domain, R is a relation and NR is a nested relation.

In Kappa (the nested relational model) :

1. We can represent tree-structure naturally.
   - It's suitable for complex structured data.
   - It's more user-friendly than the relational model.
2. We can utilize features of the relational model.
   - Extended relational algebra is available.
   - Entity-relationship concept are effective at the design and the management phases.
   - Deductive database system is implemented on Kappa.

1.2 Schema of GenBank/Kappa

Schema based on nested relational model for GenBank data is shown in Fig. 1 in detail.

gene : main table which has locus name, definition, accession, keywords, identifiers to the other tables, and so on.

reference : table which has its authors, title, journal where it has appeared, and so on.

feature : consists of a region of the sequence and its feature.

seqdata : sequence data represented in string form.

1.3 Stored Data

Data we stored for this demonstration is sequences of invertebrate, virus, bacteria and phage. The total amount is 7285 entries, 10 mega bases, and 22 mega characters in the original data, which is stored into 60 mega bytes (30 mega characters) including 10 indexes and about 16 mega bytes (8 mage characters) of *'textdata'* in Kappa.

GenBank sequence DB (89.6.15) has 26323 entries, 32 Mega bases. So it will cost about 240 mega bytes in Kappa.

2 Demonstration

2.1 Show Schema : Metadata Manipulator

We can see the schema of the database.

We show the schema of all four tables of GenBank/Kappa (gene, seqdata, reference and feature, Fig. 1) through metadata manipulator.

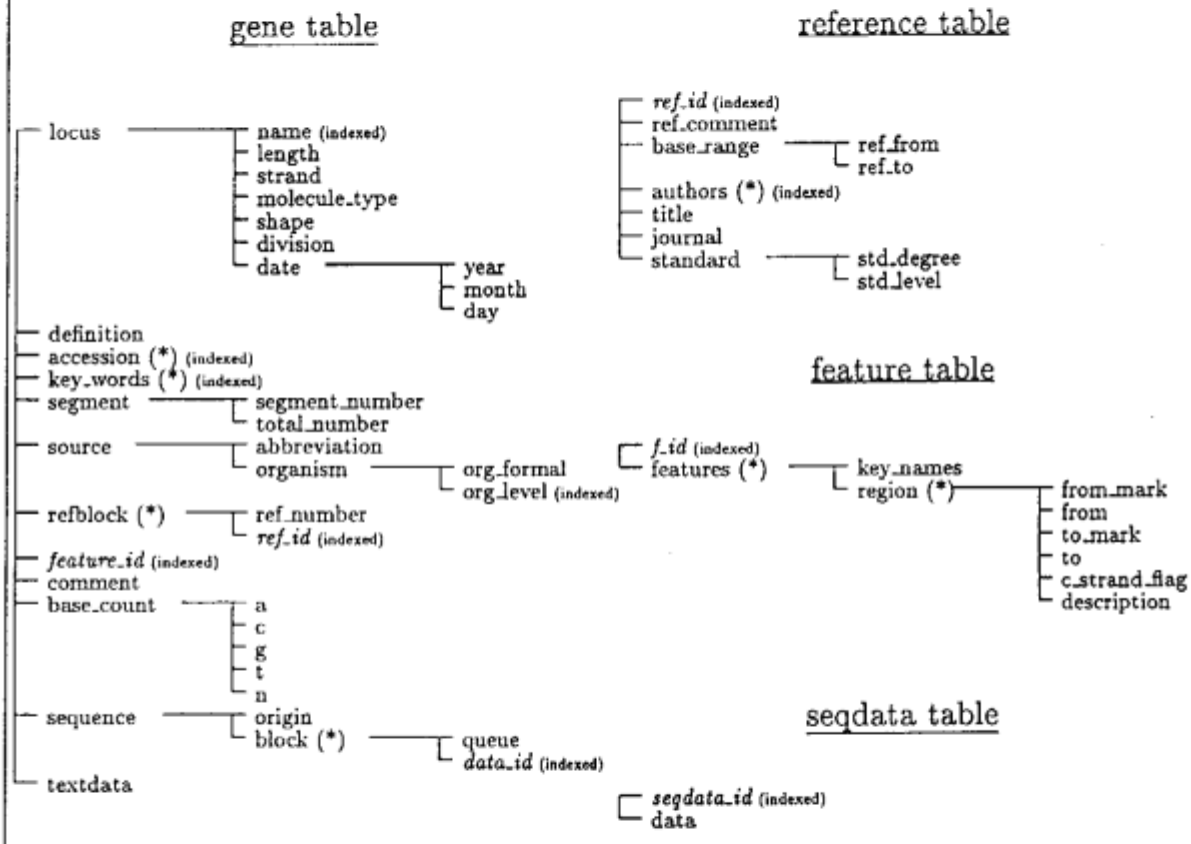


Fig. 1 *Schema of GenBank/Kappa* ('(*)' means repeating)

2.2 Display Tables : Kappa User Interface

We can see how the data is stored.

We show all four tables by projecting into smaller tables (Fig 2.1), and the contents of their attributes by clicking each cell. Kappa can have attributes with variable length directly in each record. Now in the attribute *textdata* we can see the excerpt of each flat gene data as it is in GenBank original (Fig 2.2).

Kappa can also have attributes with multi-values. So it is necessary to scroll values in the user interface.

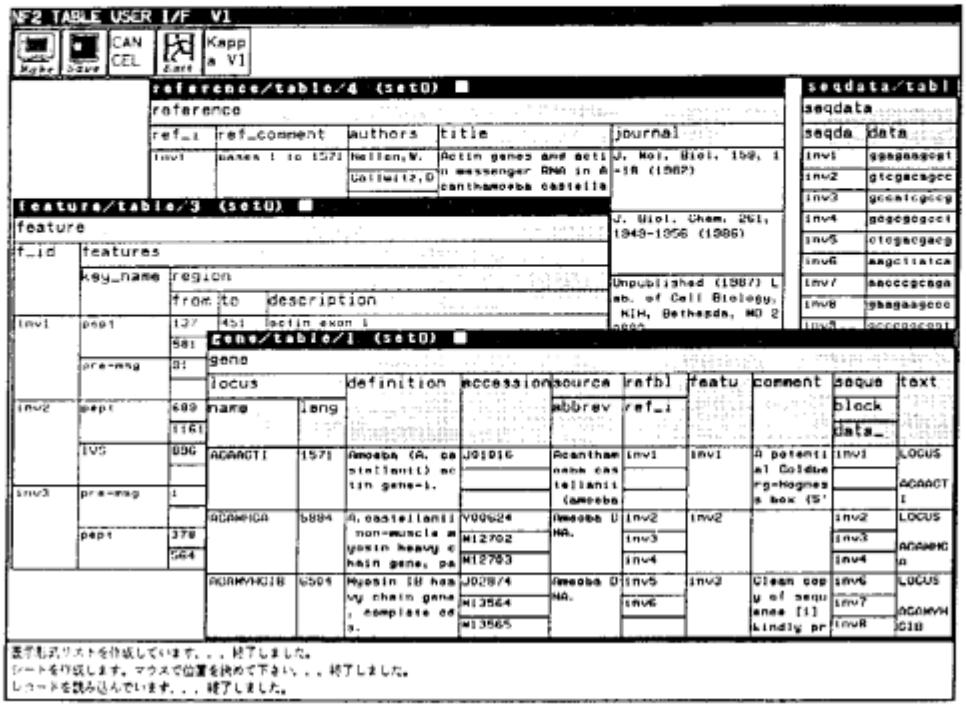


Fig. 2.1 *Kappa User Interface*

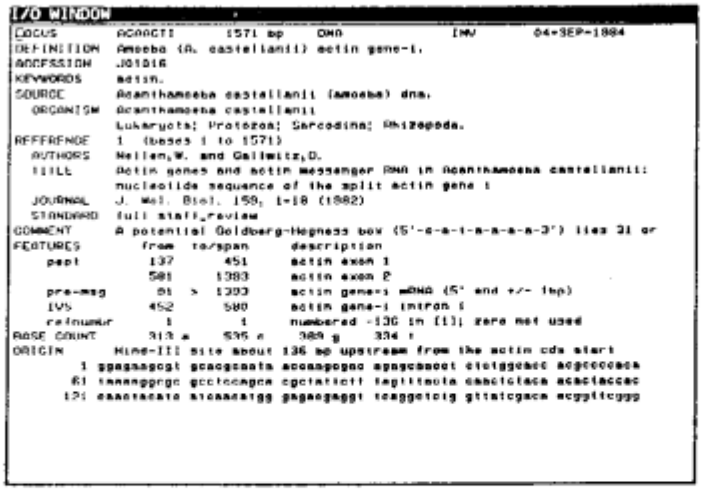


Fig. 2.2 *GenBank Original Textdata*

2.3 Retrieve Data

We can retrieve data by various conditions.

Example: make a table of genes whose reference Mr. Smith,C. writes.

$$\pi_{\text{ref\_id}}\left(\sigma_{\text{authors='Smith,C.'}}(\text{reference})\right) \bowtie \text{gene}$$

Tables and attributes are shown in Fig. 3.

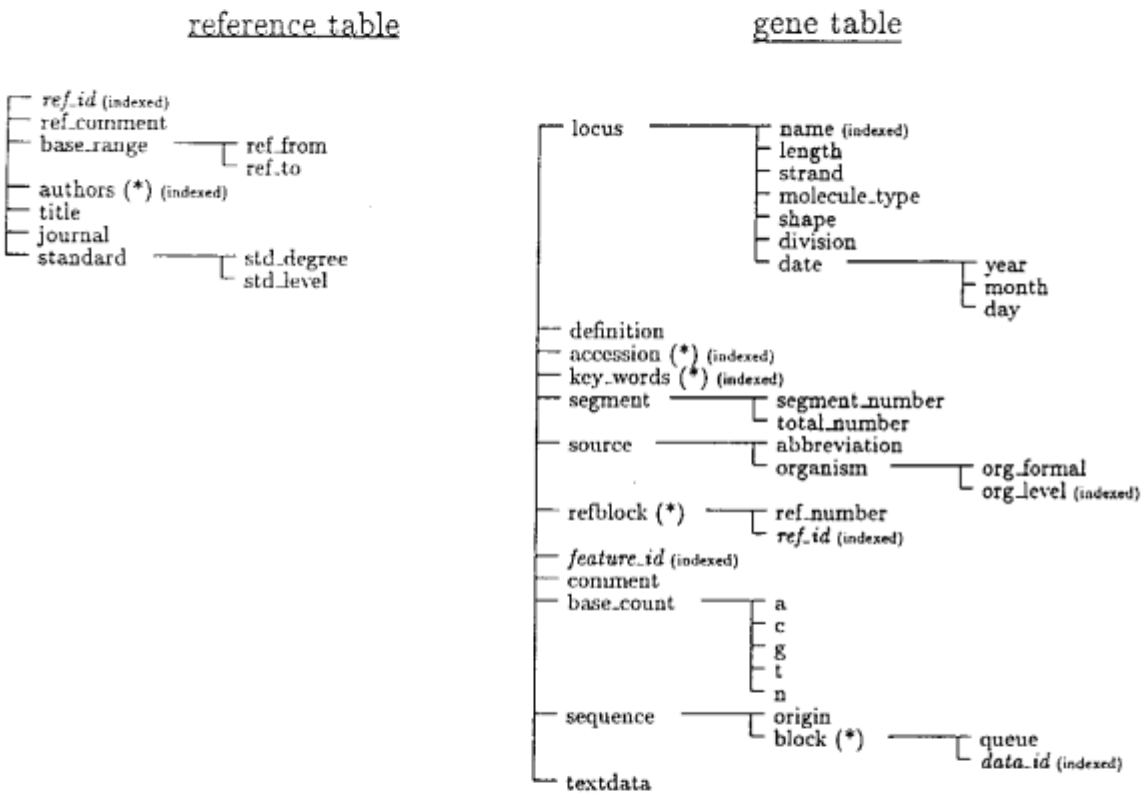


Fig. 3 *Tables and Attributes*('(*)' means repeating)

2.4 Translate into Protein & DP matching

We can translate DNA code into amino acid sequence and execute DP matching.

Flowchart is shown in Fig. 4.1.

Translation We select a DNA sequence in the feature table to translate into an amino acid sequence. The sequence is translated according to the table shown in Fig. 4.2.

DP matching We compare the *'translated'* sequence with the object sequence determined in advance. The sequences are compared according to the table selected by the user shown in Fig. 4.3 for example.

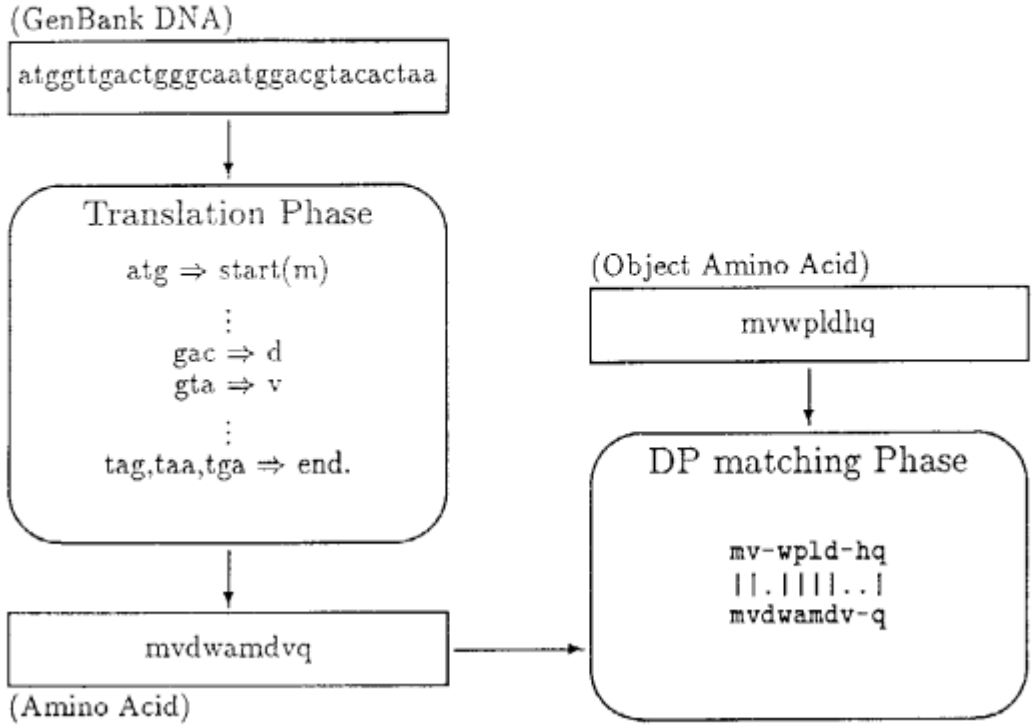


Fig. 4.1 *Translation and DP matching*

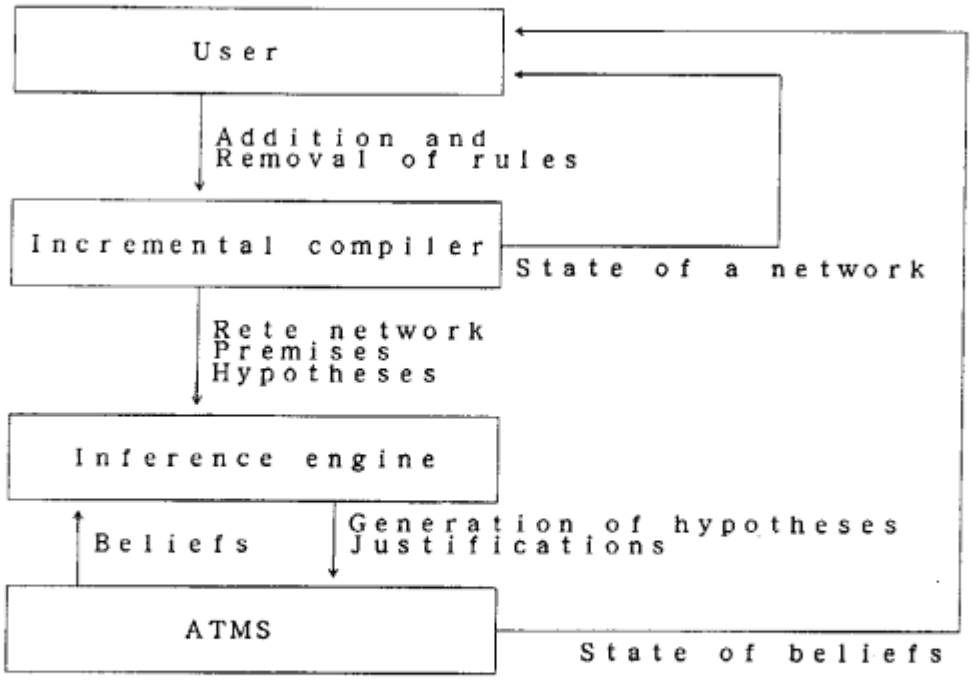
Fig. 4.2 *DNA-Amino Acid Table*

1st (5'end)	2nd T	2nd C	2nd A	2nd G	3rd (3'end)
T	f	s	y	c	T
					C
	l		*	*	A
			*	w	G
C	l	p	h	r	T
					C
			q		A
					G
A	i	t	n	s	T
					C
			k	r	A
	m				G
G	v	a	d	g	T
					C
			e		A
					G

(* terminate codon)

Fig. 4.3 *Amino Acid Difference Table*

Mutability	c	s	t	p	a	g	n	d	e
c: cysteine	6								
s: serine	4	6							
t: threonine	2	5	6						
p: proline	2	4	4	6					
a: alanine	2	5	5	5	6				
g: glycine	3	5	2	3	5	6			
n: asparagine	2	5	4	2	3	3	6		
d: aspartic acid	1	3	2	2	4	4	5	6	
e: glutamic acid	0	3	3	3	4	4	3	5	6
q: glutamine	1	3	3	3	3	2	3	4	4
h: histidine	2	3	2	3	2	1	4	3	2
r: arginine	2	3	3	3	2	3	2	2	2
k: lysine	0	3	4	2	3	2	4	3	4
m: mathionine	2	1	3	2	2	1	1	0	1
i: isoleucine	2	2	3	2	2	2	2	1	1
l: leucine	2	2	2	3	2	2	1	1	1
v: varine	2	2	3	3	5	4	2	3	4
f: phenylalanine	3	3	1	2	2	1	1	1	0
y: tyrosine	3	3	2	2	2	2	3	2	1
w: tryptophan	3	2	1	2	2	3	0	0	1

Title	**Hypothetical Reasoning System: APRICOT/0**
Purpose	The purpose of this demonstration is to show that APRICOT/0 is an efficient system in both rule compiling and hypothetical reasoning. As an example on APRICOT/0, a logic design problem is taken up.
Outline & Features	The APRICOT/0 system for hypothetical reasoning consists of an ATMS and a rule-based inference engine. The ATMS maintains consistency based on environments which are sets of assumptions. The rule-based inference engine is a forward-chaining system based on the Rete algorithm extended to handle multiple contexts. APRICOT/0 is implemented in ESP. It has the following features: 1. Generating hypotheses dynamically. 2. Avoiding redundant execution of problem-solving tasks which are shared among multiple contexts in the ATMS. 3. Allowing faster hypothetical reasoning since the two-input nodes in the Rete network keep the internal labels which are sets of environments. 4. Recompiling knowledge base faster due to incremental construction method of the Rete network.
System Configuration	

D e t a i l s (1/3)

In design problems such as logic design, many choice alternatives often appear in different levels of a hierarchy. APRICOT/0 can deal with those alternatives as hypotheses generated dynamically. As an example of logic design, the circuit calculating the greatest common divisor (G. C. D.) between two integers by using the Euclidean algorithm is taken up.

The rule set contains several kinds of knowledge: datapath design (Fig. 1), component design (Fig. 3), CMOS standard cell library (Fig. 5), and area and time constraints.

The input to APRICOT/0 is the rule set (Fig. 2, Fig. 4, Fig. 6) and output is circuits which are described by CMOS standard cells, that satisfy all given constraints.

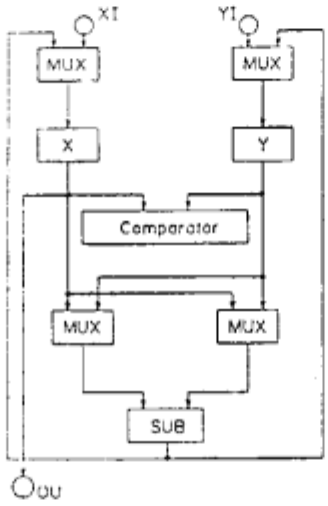


Fig. 1: An example of knowledge about block diagrams of datapaths.

```
circuit_2::
        component(dpg_ctrl_box, D_CTRL_BOX, CN1),
        component(register, REG1, CN2),
        component(register, REG2, CN3),
        component(not, NOT, CN4),
        component(multiplexer, MUX1, CN5),
        component(multiplexer, MUX2, CN6),
        component(comparator, COMP, CN7),
        component(f_Subtracter_with_MUX, SUB_with_MUX, CN8),
        cell_number(CELL_C),
        {CN1+CN2+CN3+CN4+CN5+CN6+CN7+CN8 = CELL_NUM,
         CELL_C >= CELL_NUM },
        delay_constraint(Delay_constraint),
        {       :delay(#circuit_constraint, [D_CTRL_BOX, REG1, REG2, NOT, MUX1, MUX2, C
OMP, SUB_with_MUX], Delay),
                Delay_constraint >= Delay,
                :plot(#plot, CELL_NUM, Delay)
        }
->
        circuit(2, [D_CTRL_BOX, REG1, REG2, NOT, MUX1, MUX2, COMP, SUB_with_MUX], Delay
          CELL_NUM).
```

Fig. 2: A rule representing knowledge shown in Fig. 1.

D e t a i l s (2/3)

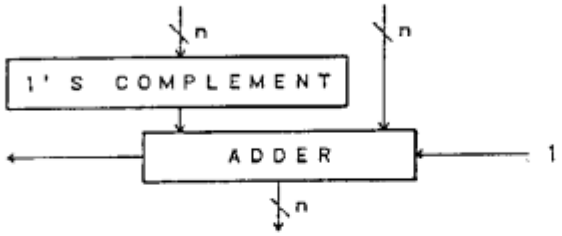


Fig. 3: An example of knowledge for component design about a subtracter.

```
component_design_f_Subtracter::
            necessary_element(subtracter),
            component(adder, ADDER, CELL_NUM1),
            component(f_1_Complementer, CMPL_1, CELL_NUM2),
            {   CELL_NUM1 + CELL_NUM2 = CELL_NUM    }
->
            assume(component(subtracter, subtracter([ADDER, CMPL_1]), CELL_NUM)).
```

Fig. 4: A rule representing knowledge shown in Fig. 3.

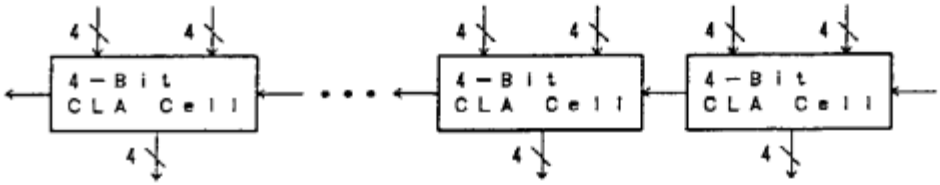


Fig. 5: An example of knowledge about an adder mapped by the CMOS standard cells.

```
technology_mapping_f_Adder_1::

            necessary_element(adder),
            cell(a4h, NUM),
            { CELL_NUM = NUM*2      }
->
            assume(component(adder, adder([a4h, a4h]), CELL_NUM)).
```

Fig. 6: A rule representing knowledge shown in Fig. 5.

Constraints on area are expressed as inequalities in the basic cell count, for example: "The total basic cell count must not exceed 400". Constraints on time are expressed as inequalities in the delay, for example: "The delay must not exceed 60 nanoseconds".

APRICOT/0 prunes the search tree earlier by the rules (Fig. 7) for incremental evaluation of constraints on area.

All solutions that satisfy all given constraints (Fig. 8) are obtained by APRICOT/0.

D e t a i l s (3/3)

```
circuit_constraint000::
        component(dpg_ctrl_box, D_CTRL_BOX, CN1),
        component(register, REG1, CN2),
        cell_number(CELL_NUM),
        {       CN1+CN2 > CELL_NUM                      }
->
        [].

circuit_constraint00::
        component(dpg_ctrl_box, D_CTRL_BOX, CN1),
        component(register, REG1, CN2),
        component(register, REG2, CN3),
        component(not, NOT, CN4),
        component(multiplexer, MUX1, CN5),
        component(multiplexer, MUX2, CN6),
        cell_number(CELL_NUM),
        {       CN1+CN2+CN3+CN4+CN5+CN6 > CELL_NUM      }
->
        [].

circuit_constraint10::
        component(dpg_ctrl_box, D_CTRL_BOX, CN1),
        component(register, REG1, CN2),
        component(register, REG2, CN3),
        component(not, NOT, CN4),
        component(multiplexer, MUX1, CN5),
        component(multiplexer, MUX2, CN6),
        component(comparator, COMP, CN7),
        cell_number(CELL_NUM),
        {       CN1+CN2+CN3+CN4+CN5+CN6+CN7 > CELL_NUM  }
->
        [].
```

Fig. 7: Rules for incremental evaluation of constraints on area.

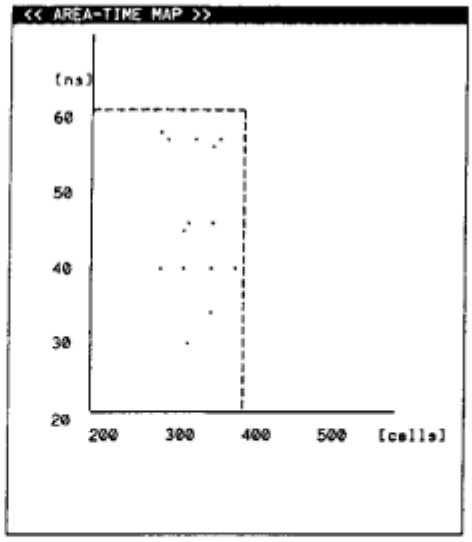
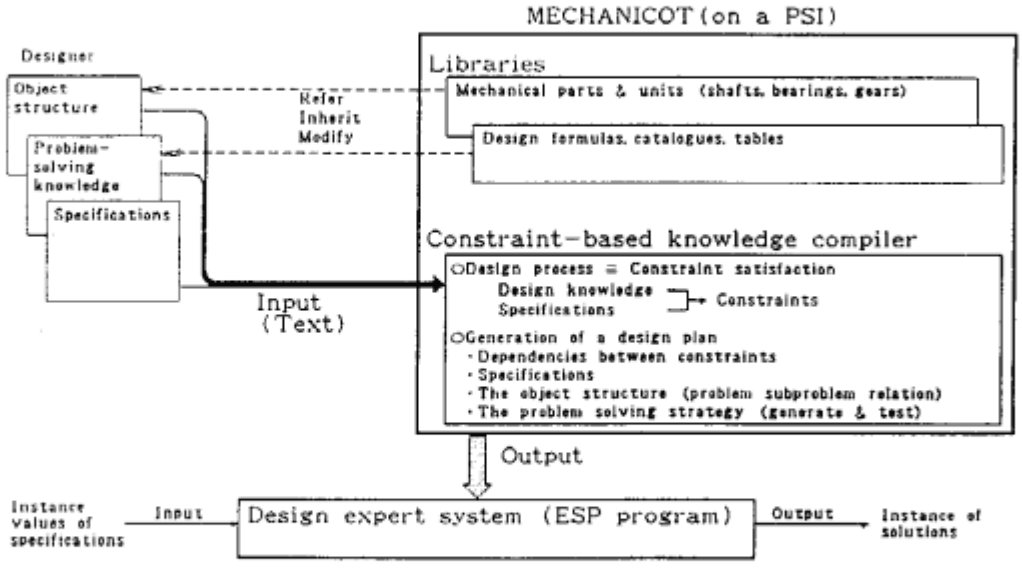


Fig. 8: Mapping all solutions on time-area.

Reference

F. Maruyama, et al., "co-LODEX: A Cooperative Expert System for Logic Design", Proc. of FGCS '88 Vol. 3, pp.1299–1306 (1988).

Title	**Constraint-based Knowledge Compiler – MECHANICOT –**
Purpose	The purpose of this research is to consider constraints as a knowledge representation and to apply the constraint problem-solving paradigm to practical problems. The focus of the research is to generate a plan for problem solving from declarative knowledge (constraint) representation.
Outline & Features	When knowledge is described as constraints, it is easy to understand and maintain it, since knowledge is expressed in a declarative form. However, it is hard to obtain efficiency in problem solving, because most declarative representations lack control information such as the strategy of problem solving. The constraint-based knowledge compiler (KC) provides facilities to overcome this problem. The KC regards knowledge as constraints, and generates a plan for problem solving by analyzing dependencies between constraints. The inputs to the KC are explicit knowledge written in a frame-like language and the output is a program written in ESP, which is a *problem-solving plan* generated by the KC. To generate a *problem-solving plan*, the KC uses: • Constraints • Input parameters • The hierarchy of problem decomposition (problem subproblem relations) • A problem-solving strategy (generate and test, in this case) MECHANICOT is a prototype KC, which is applied to a mechanical design.
System Configuration	

D e t a i l s (1/3)

□Purpose of this research
- ○Constraints ≡ Declarative knowledge representation
- ○To apply the constraint problem-solving paradigm to practical problems

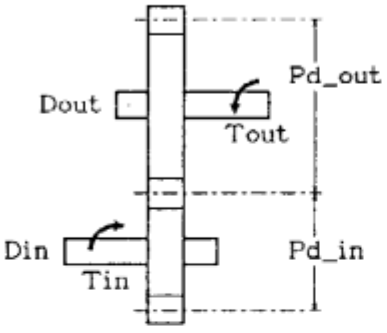
□Declarative knowledge (constraints) ⇔ Efficiency of problem solving
- ◎To generate a plan for efficient problem solving from given constraints

□Constraint-based knowledge compiler
- ○Regarding knowledge as constraints
- ○Generation of a problem-solving plan
  - · Constraints
  - · Input parameters
  - · The hierarchy of problem decomposition (problem subproblem relations)
  - · The problem solving strategy (generate and test)

□MECHANICOT
- ○Application of the knowledge compiler to a mechanical design
- ○Characteristic of routine design

  Design knowledge
  Design specification → Constraints
- ○Each design leads to a different design plan

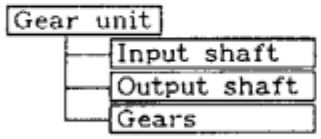
【Example of design (gear unit)】



□Specification (Input)
- · Moment: Tin, Tout
- · Shearing strength: Gin, Gout
- · Torsion angle: θin, θout
- · Input revolution: Rin

□Design parameter (Output)
- · Gear ratio: Rg
- · Gear pitch diameter: Pd_in, Pd_out
- · Shaft diameter: Din, Dout
- · Output revolution: Rout

□Knowledge of object structure
- ○Problem subproblem relation



- ○Connective relation

  To build the unit,

  Din = (Hole diameter of input gear)

  Dout= (Hole diameter of output gear)

D e t a i l s (2/3)

□Knowledge for problem solving

○Gear ratio
Rg=Tout/Tin

○Output shaft revolution
Rout=Rin/Rg

○Shaft diameter

$$Din = \sqrt[4]{\frac{32Tin \times 180 \times 1000}{\pi Gin \times \theta in}} \qquad Dout = \sqrt[4]{\frac{32Tout \times 180 \times 1000}{\pi Gout \times \theta out}}$$

○Gear module
m_gen(Module) % Select a value from the standard value set
% {2.0, 2.5, 4.0, 5.0, 6.0}

○Gear pitch diameters
Pd≧(shaft diameter)+7×(module)
Pd≦2000/π×(shaft revolution)

⇩

Pdmin_in=Din+7m Pdmin_out=Dout+7m
Pdmax_in=2000/πRin Pdmax_out=2000/πRout

pd_gen(Pdmin, Pdmax, Pd)
% pd_gen: Generate a value between Pdmin and Pdmax

○Gear ratio
Rg=Pd_out/Pd_in

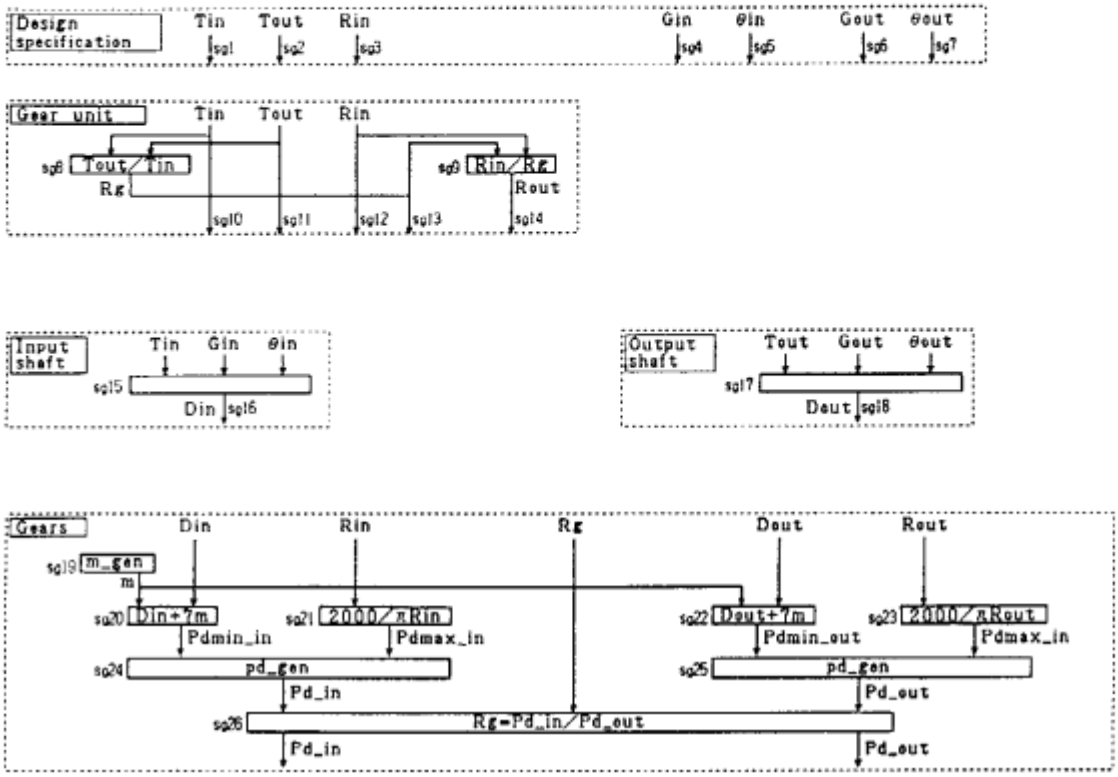
[Input of MECHANICOT]

```
class_name
     gear_unit:

consist_of     % design object structure
     input_shaft,
     output_shaft,
     gear:

parameter      % input & output parameter
     tin, tout, rin, rg, rout:

constraint     % structual constraint
     tin  = #input_shaft!tin,
            % (#) class (!) parameter
     tout = #output_shaft!tout,
     rin  = #gear!rin,
     rout = #gear!rout,
     rg   = #gear!rg:

design_method
    ([rg],
     rg=tout/tin
    ),
    ([rout],
     rout=rin/rg
    ):

end.
```

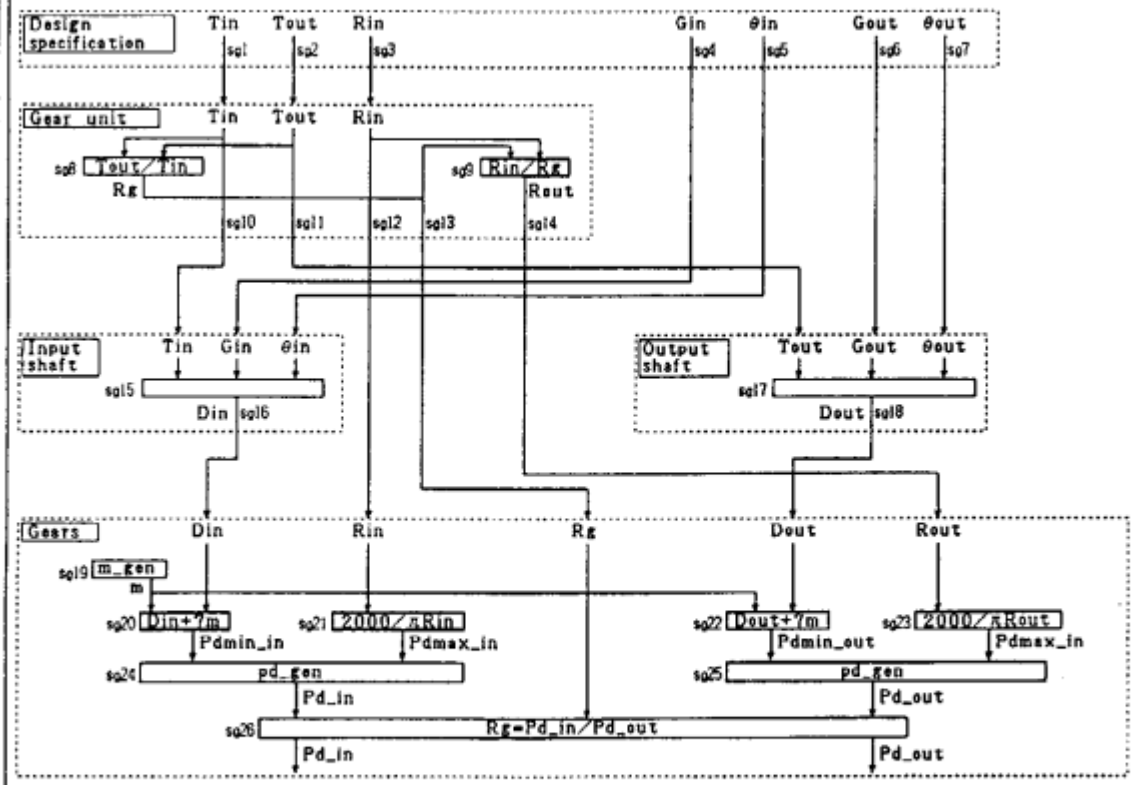
```
class_name
     input_shaft:

parameter
     tin, gin, θin, din:

constraint
     din = #gear!din;
           % (#) class (!) parameter

design_method
   ([din],
    din = ((32*tin*180000)
           /(9.87*gin*θin))**0.25
   ):

end.
```

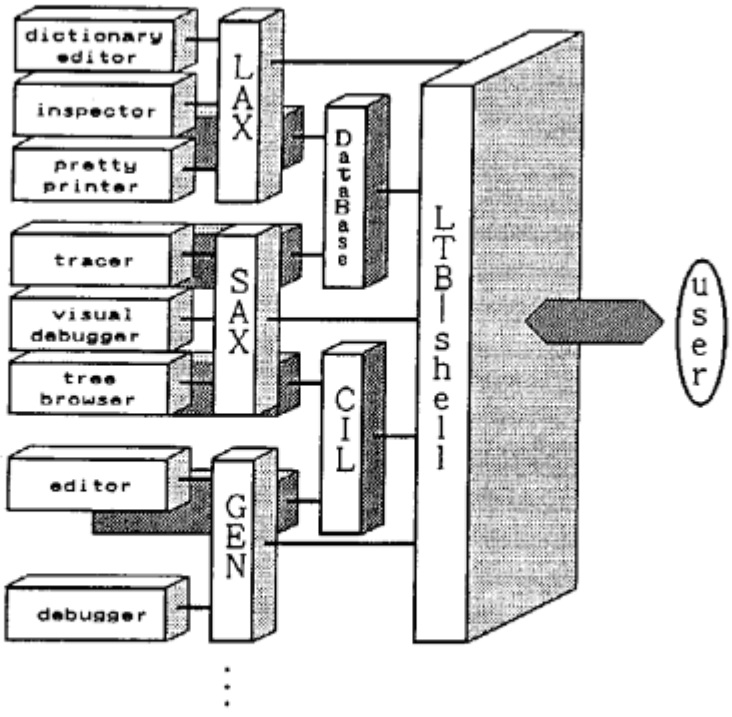
D e t a i l s (3/3)

【Intermediate result of analysis】



【Result of analysis】



Title	A Software Library for Japanese Language Processing LTB
Purpose	LTB(Language Tool Box) provides an efficient development environment for basic and general modules for analysis, generation etc.
Outline & Features	◦ Modules **LAX:** The morphological and semantic analyzer. **SAX:** Syntactic and semantic analyzer. The grammar is written in DCG. **GEN:** Japanese sentence generator. The input is a frame structure written in **CIL**. **CIL:** Basic programming language of the LTB. Every tool in the LTB has access to **CIL** and its programming environments. **DataBase:** The dictionary and the thesaurus, both of which are referred by both analysis modules and the generation module. **Shell:** The **LTB-shell** coordinates the operation of every module in a uniform way, and it manages communications between any two modules. ◦ Development environment **Editors:** edit rules, dictionary, input/output data. **Tracers:** trace the execution of LTB modules. **Inspectors:** inspect the system state during/after the execution. **Pretty Printers:** display the data on the screen.
System Configuration	

A Scenario of the Demonstration

Analyzing sentences:

- ◇ LAX analyzes an input sentence, and transforms it into a sequence of phrases.
- ◇ SAX analyzes this sequence of phrases, which is the output of LAX, and constructs its semantic structure.

Generating sentences:

- ◇ GEN generates a Japanese sentence. The input is a frame structure, called **Intermediate Representation**.

Sample sentences:

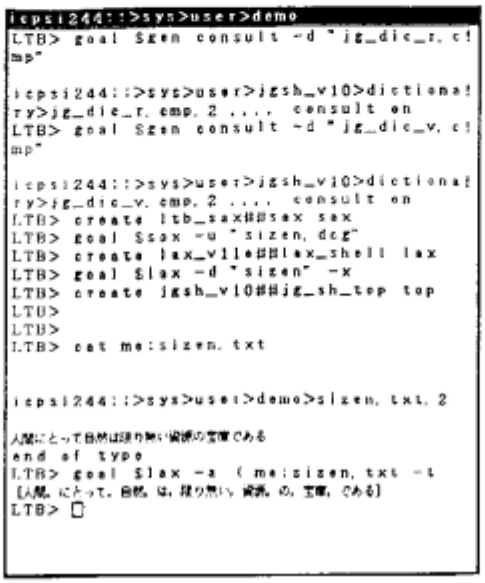
Japanese: 人間にとって自然は限り無い資源の宝庫である。
pronounciation: Ningen-ni totte sizen-wa kagirinai sigen-no hôko-dearu.
English: For man, nature is a treasure house of unlimited resources.
intermediate representation:

```
{関係 /{語彙 /である },
 rel     lex   'be'
 ロール /{記述対象 /{補語 /{語彙 /自然 }},
 role      topic      comp  lex   'nature'
           内容 /{   補語 /{被修飾 /{被修飾 /{語彙 /宝庫 },
           content   comp  modifee modifee lex   'treasure-house'
                                   連体修飾 /{語彙 /資源 }},
                                   modifier lex   'resource'
                           連体修飾 /{関係 /{語彙 /限り無い }}}},
                           modifier rel     lex   'unlimited'
           様態 /{   表層 /にとって,
           manner    surf  'for'
                     補語 /{語彙 /人間 }}}}
                     comp  lex   'man'
```

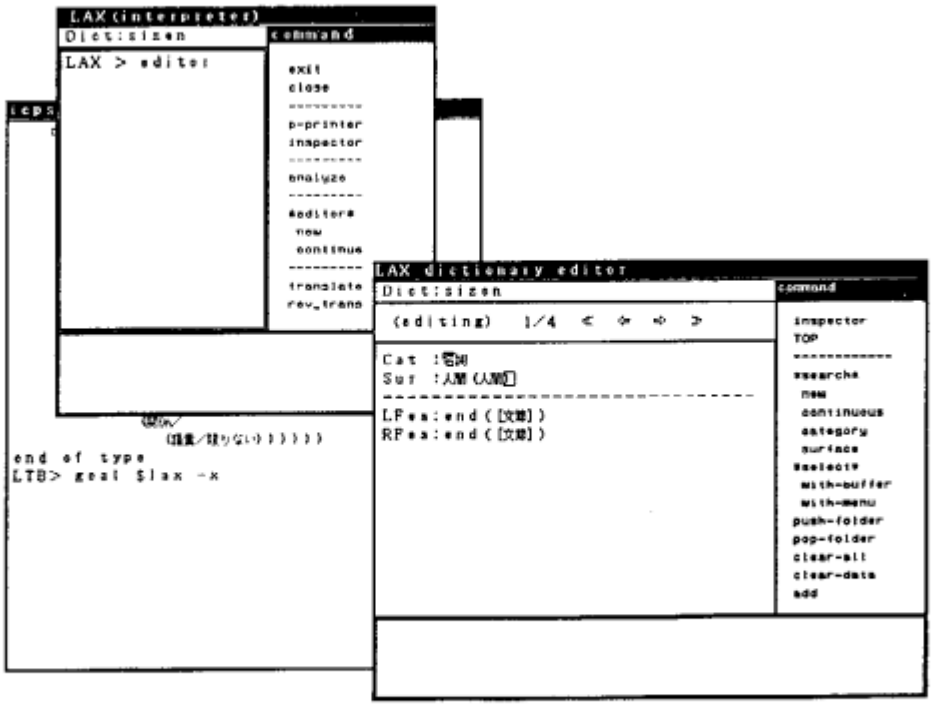
D e t a i l s (2/3)

Development environment:

LTB-shell:

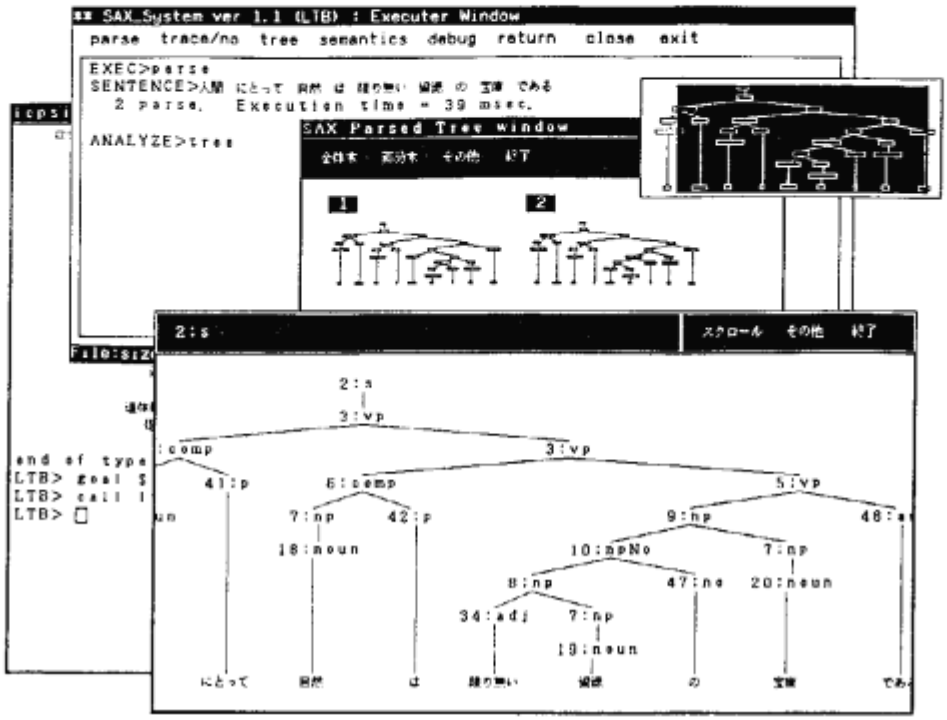


LAX - dictionary editor:



D e t a i l s (3／3)

SAX - tree browser:



GEN - debugger: