Intelligent Systems: Reasoning and Recognition

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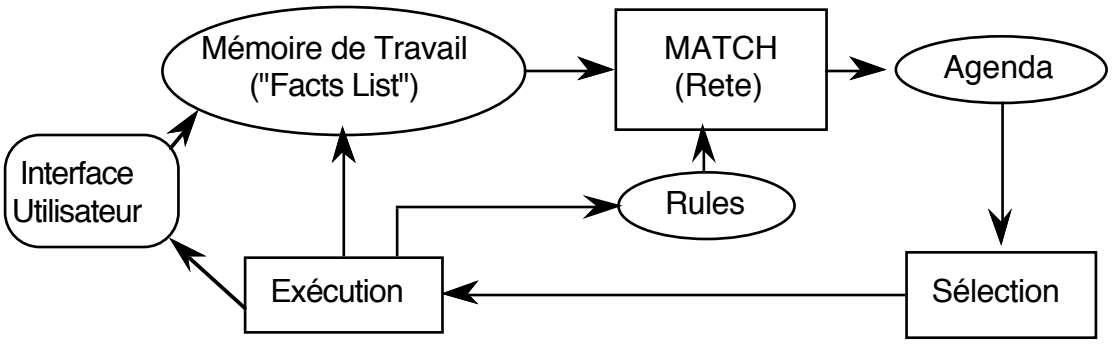
Rule based programming - Introduction to CLIPS 6.0

Production System Architecture



The system implements an "inference engine" that operates as a 3 phase cycle:

The cycle is called the "recognize act" cycle.
The phases are:

MATCH: match facts in Short Term memory to rules
SELECT: Select the correspondence of facts and rules to execute
EXECUTE: Execute the action par of the rule.

CLIPS : “C Language Integrated Production System”

deffacts

A predefined list of facts can be created by the expression "deffacts".

(deffacts <NOM> ["<comment>"]
[(<<FAIT-1>>) (<<FAIT-2>>) ... (<<FAIT-N>>))

the command (reset) will empty the facts list and create an "initial-fact" and to create the list of default facts.

examples :

```
(deftemplate place
    (slot name (type SYMBOL) (default NIL))
    (slot x (type NUMBER) (default -1))
    (slot y (type NUMBER)(default -1))
    (multislot neighbors (default NIL))
)

(deffacts network-of-places
    (place (name A) (x 0) (y 0) (neighbors B C))
    (place (name B) (x 0) (y 1) (neighbors A D))
    (place (name C) (x 1) (y 0) (neighbors A I))
)

CLIPS> (deffacts network-of-places
    (place (name A) (x 0) (y 0) (neighbors B C))
    (place (name B) (x 0) (y 1) (neighbors A D))
    (place (name C) (x 1) (y 0) (neighbors A I))
)
CLIPS> (reset)
CLIPS> (facts)
f-0     (initial-fact)
f-1     (place (name A) (x 0) (y 0) (neighbors B C))
f-2     (place (name B) (x 0) (y 1) (neighbors A D))
f-3     (place (name C) (x 1) (y 0) (neighbors A I))
For a total of 4 facts.
```

Rules in CLIPS

CLIPS rules allow programming of reactive knowledge.
Rules are defined by the "defrule" command.

```
(defrule <rule-name> [<comment>]
      [<declaration>]                ; Rule Properties
      <conditional-element>*         ; Left-Hand Side (LHS)
=>
      <action>*)                     ; Right-Hand Side (RHS)
```

If the rule with the same name exists, it is replaced.
else the rule is created.

There is no limit to the number of conditions or actions (* means 0 or more).
Actions are executed sequentially.

Rules with no condition are activated by (Initial-Fact)

The syntax for condition elements is complex:

```
<conditional-element> ::= <pattern-CE> |
                          <assigned-pattern-CE> |
                          <not-CE> |
                          <and-CE> |
                          <or-CE> |
                          <logical-CE> |
                          <test-CE>
```

A condition element (CE) can be a list or a template or user defined object.

List: (<constant-1> ... <constant-n>)
Deftemplate:

```
(<deftemplate-name> (<slot-name-1> <constant-1>)
                                   •
                                   •
                                   •
                    (<slot-name-n> <constant-n>))
```

A CE can contain constant values or variables.

Variables

Variables are represented by ?x
There are two sorts of variables in CLIPS:

Index Variables: are assigned the index of a fact that matches a CE.
Attribute Variables: Contain the value of a item that matched a CE.

Index Variables

Variable : ?x

Index variables are used to identify a fact that has matched a CE
This can be used to retract of modify the fact.

```
(defrule rule-A
   ?f <- (a)
=>
   (printout t "Retracting  " ?f  crlf)
   (retract ?f)
)

(deftemplate A (slot B (default 0)))

(defrule rule-A
   ?f <- (A (B 0))
=>
   (printout t "Changing  " ?f  crlf)
   (modify ?f (B 1))
)
```

Attribute Variables

Attribute variables are assigned the value of an item that matched a CE.
These can be used to

1) Recover the value for computation
2) Detect matching facts.

Syntax for attribute variables.

?var - Defines a variable named var.
The matching value is assigned to ?var.
$?list -Defines a list of variables named list
? - An unnamed variable. No data is stored.
$? - An unnamed list. no data is stored.

WITHIN condition elements, values implicitly bound to variables.
Examples :

```
(assert (a b c))
(assert (a b c d e f))
(assert (d e f))

(defrule choose-1
   (a)
=>
(printout t "a b c" crlf)
)


(defrule choose-1
   (a b c)
=>
(printout t "a b c" crlf)
)

(defrule choose-3
   (a b ?x)
=>
(printout t "a b  and ?x = " ?x crlf)
)
```

```
(defrule choose-1-of-3
   (a ?x  ?)
=>
(printout t "x = " ?x crlf)
)

(defrule process-a-list
   (a $?x)
=>
(printout t "The list is " $?x crlf)
)

(defrule make-a-big-list
   (a $?x $?)
=>
(printout t "The list is " $?x crlf)
)
```

The following "trick" is used to obtain the elements of a list:

```
(defrule process-a-list2
   (a $? ?x $?)
=>
(printout t "x = " ?x crlf)
)

(defrule increment-x
  ?f <- (a ?x)
=>
   (printout t "x = " ?x crlf)
   (bind ?x (+ ?x 1))
   (printout t "now x = " ?x crlf)
   (retract ?f)
   (assert (a ?x))
)

(defrule increment-x-example
  ?f <- (a ?x)
=>
   (printout t "x = " ?x crlf)
```

```
  (bind ?x (+ ?x 1))
  (printout t "now x = " ?x crlf)
  (modify ?f (a ?x))
)

(deftemplate a (slot x))

(defrule increment-x-exampls
  ?f <- (a (x ?x))
=>
  (printout t "x = " ?x crlf)
  (bind ?x (+ ?x 1))
  (printout t "now x = " ?x crlf)
  (modify ?f (x ?x))
)
```

WITHIN the action part of a rule, values may be assigned by
(bind ?Var Value)
e.g. (bind ?x 3) assigns 3 to ?x

ATTN: DO NOT use (bind) in condition elements

```
(defrule test
?c <- (a b c)
=>
(bind ?c oops)
(printout t ?c crlf)
)
```

Rule Activations (associations of a rule with facts that match conditions)
are placed on the agenda.

```
(deftemplate person
    "A record for a person"
    (slot family-name)
    (slot first-name)
)

(assert (person (family-name DOE) (first-name John)))
(assert (person (family-name DOE) (first-name Jane)))
```

```
(defrule Find-same-name
    ?P1 <- (person (family-name ?f) (first-name ?n1))
    ?P2 <- (person (family-name ?f) (first-name ?n2))
=>
    (printout t  ?n1 " " ?f" and  " ?n2 " " ?f " have the
same family name" crlf)
)
```

CLIPS> (assert (person (family-name DOE) (first-name John)))
<Fact-1>
CLIPS> (assert (person (family-name DOE) (first-name Jane)))
<Fact-2>

```
CLIPS> (defrule Find-same-name
    ?P1 <- (person (family-name ?f) (first-name ?n1))
    ?P2 <- (person (family-name ?f) (first-name ?n2))
=>
    (printout t  ?n1 " " ?f" and  " ?n2 " " ?f " have the
same family name" crlf)
)
CLIPS> (run)
Jane DOE and  Jane DOE have the same family name
Jane DOE and  John DOE have the same family name
John DOE and  Jane DOE have the same family name
John DOE and  John DOE have the same family name
```

Question: Why does the rule execute 4 times?

```
(defrule Find-same-name
    ?P1 <- (person (family-name ?f) (first-name ?n1))
    ?P2 <- (person (family-name ?f) (first-name ?n2))
    (test (neq ?n1 ?n2))
=>
    (printout t  ?n1 " " ?f" and  " ?n2 " " ?f " have the
same family name" crlf)
)
```

Rule Syntax: Constraints

Variable assignment and matching in conditions can be "constrained" by constraints.

There are two classes of constraints: "Logic Constraints" and Predicate Functions

Logic Constraints are composed using"&", "|", "~"

"&"- AND - Conjunctive constraint
"|" - OR - Disjunctive Constraint
"~" - NOT - Negation

```
(defrule Find-same-name
    ?P1 <- (person (family-name ?f) (first-name ?n1))
    ?P2 <- (person (family-name ?f)
        (first-name ?n2&~?n1))

=>
    (printout t  ?n1 " " ?f" and  " ?n2 " " ?f " have the
same family name" crlf)
)
```

example :
(?x & green | blue) - ?x must be green or blue for the condition to match
(?x & ~red) - ?x cannot match red.

```
(defrule Stop-At-Light
  (color ?x & red | yellow)
=>
  (assert (STOP))
  (printout t "STOP! the light is " ?x crlf)
)
 (assert (color red))
```

Predicates

Predicates provide functions for defining constraints.
For Predicate functions, the variable is followed by ":".

(?x&:(<predicate> <<arguments>>)	The condition is satisfied if 1) a value is assigned to ?x , and 2) the predicate is true for arguments
(?x|: (<predicate> <<arguments>>)	The condition is satisfied if 1) a value is assigned to ?x , or 2) the predicate is true for arguments
(?x&~(<predicate> <<arguments>>)	The condition is satisfied if 1) a value is assigned to ?x , and 2) the predicate is false for arguments

```
(defrule Find-same-name
    ?P1 <- (person (family-name ?f) (first-name ?n1))
    ?P2 <- (person (family-name ?f)
       (first-name ?n2&:(neq ?n1 ?n2)))

=>
    (printout t  ?n1 " " ?f" and  " ?n2 " " ?f " have the
same family name" crlf)
)
```

There are many predefined predicates. For example.

(numberp <arg>) - true if <arg> is a PRIMITIVE of type NUMBER
(stringp <arg>) - true if <arg> is a PRIMITIVE of type STRING
(wordp <arg>) - true if <arg> is a PRIMITIVE of type WORD

Additional functions can be found in the manual

```
(defrule example-1
  (data ?x&:(numberp ?x))
  =>)

(defrule example-2
  (data ?x&~:(symbolp ?x))
  =>)

(defrule example-3
```

```
  (data ?x&:(numberp ?x)&:(oddp ?x))
  =>)

(defrule example-4
  (data ?y)
  (data ?x&:(> ?x ?y))
  =>)

(defrule example-4
     (data ?y)
 not (data ?x&:(> ?x ?y))
  =>)


(defrule example-5
  (data $?x&:(> (length$ ?x) 2))
  =>)
```