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Short Note

EμPS Compiler for Procedural Description of Flow Control Entirely Segregated from the Rules

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This paper proposes a new programming paradigm EμPS for implementing rule-based production systems as a set of named rule clusters and a separate procedural description of flow at the level of the clusters. The procedural description is compiled into a main rule cluster which governs the flow via goal-settings generated by the compiler.

1. Introduction

Since the advent of rule-based Production System (PS),[2),5)] the problem of procedural flow control has been of serious concern. Proposed and in use so far are basically a variety of means of implementing the flow in its most primitive form of a network of inter-cluster GOTO's,[1),3),4),7)] and purely procedural frameworks in which the user can interact with the PS.[6),8),9),11)]

This paper proposes a general programming paradigm EμPS that allows description of flow at the rule-cluster (cluster) level in procedural constructs in a form entirely segregated from the rules.

The procedural description of flow is compiled into a main cluster, as a set of rules that calls via goal-settings generated by the compiler the clusters each implemented and named for a task. A compiler has been experimentally implemented and the output of the compiler is a source program in an OPS family language μPS.

Presented in the following are the programming style, sample outputs and key design concept of the compiler, and experiences on two practical examples.

2. EμPS Environment

In the EμPS environment proposed, the entire PS is written as in the following for compilation.

```
DEFINE MAIN
  Procedural description of flow
  at the level of the clusters
END
DEFINE CLUSTER Cluster_name_1
  Rules for task 1
END
------
------
------
DEFINE CLUSTER Cluster_name_n
  Rules for task n
END
```

The compiler compiles the procedural descriptions into rules working as the "MAIN" cluster. And it processes the rules in the task clusters to insert condition elements into the LHS and actions into the RHS to implement goal-settings for the flow control intended.

Figure 1 shows sample outputs of the compiler showing a rule produced for a construct "FIRE Cluster_X" that calls a "Cluster_X" cluster in the MAIN program. And **Fig. 2** shows how the compiler manipulates a rule in the "Cluster_X" cluster with "DONE" in its RHS for returning to the main program.

It is possible to compile any procedural constructs in the MAIN program, and among the constructs compilable on the experimentally implemented compiler are Conditional/Unconditional call by name of a named cluster, Subroutine Call, Repeat-Until, etc.

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Aimed at in the EμPS environment is to provide the user with a powerful tool for automatic generation of goal-settings for flow control of any depth and complexity. It is powerful in the same sense as a conventional language compiler is powerful in saving mannual works mandatory in an assembly language environment.

The key design concept of the EμPS environment is to divide the MAIN cluster into subclusters each representing a line of the MAIN program. The flow control among the subclusters is made by goal-settings generated by the compiler using a control WME of class line__ storing implicit logical line numbers in its attribute ^number.

For calling a task-cluster in each subcluster for a line, another control WME of class fire__ is used for goal-setting (again generated by the compiler). To call a task-cluster, the attribute ^now of this WME is set to the name of the cluster to which control is transferred. In the cluster called, all the rules have a condition element to match the cluster name. And upon completion of the task, a rule in it with "DONE" in the RHS sets the cluster name back to MAIN.

```
(t1) FIRE Cluster_X
(t2) .......

-->            DEFINE RULE Line_t1
               IF
                &fire__     ^now=|MAIN|
                &line__     ^number=t1
               THEN
                MODIFY fire__   ^now t2
                MODIFY line__   ^number t3
               END
```

Fig. 1 The rule produced for a cluster call "FIRE Cluster_X". The t1 is numerals for the logical line number of the current line, t2 is the name "Cluster_X", and t3 is numerals for the logical line number of the next line.

```
DEFINE RULE Rule_name
 IF
  &..............
 THEN
  ...............
  DONE
 END

-->            DEFINE RULE Rule_Name
                IF
                 &..............
                 &fire__^now=|Cluster_X|
                THEN
                 ...............
                 MODIFY fire__  ^now |MAIN|
               END
```

Fig. 2 Insertions made by the compiler to a rule with a "DONE" in its RHS in the "Cluster_X" cluster.

All the rules in the MAIN cluster have a condition element to match the name MAIN, and upon return to it only these rules in the subcluster for the next line are instantiated according to the value of the attribute ^number of the control WME line__.

For implementing a Subroutine Call in the MAIN program, the logical line number of the line at which the call is made is pushed down into a Call Stack implemented using still another control WME. Nested REPEAT-UNTIL constructs require stacking operations as to the logical line numbers and values of the control variables, and means of checking the values of the control variables must be provided.

In the EμPS environment declarations and Make/Update actions upon those WME's for the stacks and other control mechanisms are automatically generated by the compiler.

3. Preliminary Experiments

Two sample PS's, one for Room Assignment (of 43 rules+52 line MAIN Program compiled into 123 rules in all), and another for simple Job Shop Scheduling(of 59 rules+30 line MAIN Program compiled into 93 rules in all), have been implemented, and the Job Shop Scheduler has been in trial use.

In both of the sample PS's, it took only a day to write and another day to debug the main flow at the level of task-clusters. And the implementor used all the rest of the time working on the task-clusters.

4. Conclusion

The proposed programming paradigm EμPS provides a means of describing procedural flow at the level of cluster in a form entirely segregated from the rules.

Explicit and implicit inter-cluster GOTO's implementable by proviously proposed means are not for readability. And direct interactions with the internal mechanisms of the PS in a procedural environment tend to be detrimental to the beauty of the basic concept of PS.

EμPS provides an essential and practical solution for the problem, and it now allows the user to implement intricate PS's with great ease implementing independent task clusters and describing the flow at the level of clusters in an well structured procedural form.

Recent advent of Rule Chip[10] forecasts a clear possibility of practical implementation of Rete Chip. A combination of EμPS and a Rete Chip would be an ideal environment for large, intricate, and speed conscious PS's.

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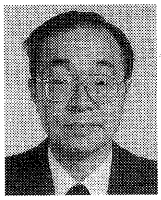

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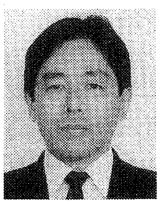

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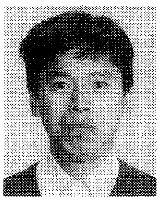

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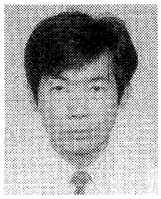

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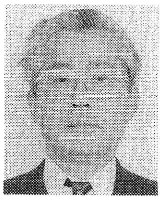

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