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The Study of ECA Rules System Model Based on Petri Nets

AI DiMing¹, GAO XiuFeng²

¹Ordinance Technology Institute, Ordinance Engineering College,
shijiazhuang 050003 China

²Department of Computer, Ordinance Engineering College, shijiazhuang
050003 China

Email: { Aiyangmei,Gaoxiufeng}@vip.sina.com

Abstract: The active functions of aDBS (active Database System) are currently achieved by ECA rule system. But it is difficult for ECA rules system to be analyzed and validated. And there is no perfect model today. Based on the Petri Net, This paper thinks over the character of rules system, and establishes a system model. And some behaviors are analyzed in this paper.

Key words: aDBS, ECA rules, Petri Nets

1. INTRODUCTION

Usually active database system adopts active rules to realize active function, while typically active rule uses ECA rules modeling^{1,2}. Complexity of ECA rule system is due to its complicated behavior. When rule is active and action is executed depends on coupling mode and coordination of rules.

At present, rule execution diagram analysis method is applied to ECA rule system, such as trigger diagram, activation diagram, and etc³, however, it can only plot trigger and activation relation between rules, and cannot materialize trigger and activation procedure of each rule. Therefore, this method cannot reflect feature of ECA rule itself, and cannot show complexity of rule system behavior indeed. On the other hand, Petri net possesses good formalization basis, it can describe change of system states, and has quite mature analysis theory. Although there are already similar references that use Petri net technology to analyze ECA rule system

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modeling, for instance, reference 4 put forward Constraint Place/Transit Net, (shortened as CP/T Net), and use the Net to make modeling analysis on active rule, however, it did not consider coupling relation of event-condition-action.

This paper, on basis of Petri net, make modeling research on ECA rule; it puts forward a kind of extension Petri net system, and with which it builds ECA rule modeling, it can reflect feature of ECA rule modeling itself fully.

2. BASIC PETRI NET MODEL OF ECA RULE

2.1 Basic principle of Petri net

Petri net, brought forward firstly in his doctoral thesis by Mr. C.A. Petri in 1962, is used for describing the relationship between computer events and the precedence, parallel and a synchronism relationships between complex events in discrete event system and can easily be used for describing the following events, such as resource conflicts, deadlock and buffer size in manufacturing system.

Definition 2.1 Petri net is a 3-tuple group

$$N = (S, T; F)$$

in which S and T are known as the place set and the transition set respectively and, F is the flow relation. The necessary and sufficient conditions are5:

$$S \cap T = \Phi$$

$$S \cup T \neq \Phi$$

$$F \subseteq S \times T \cup T \times S$$

$$\text{dom}(F) \cup \text{cod}(F) = S \cup T$$

Here:

$$\text{dom}(F) = \{x \mid \exists y: (x, y) \in F\},$$

$$\text{cod}(F) = \{y \mid \exists x: (x, y) \in F\}$$

are domain of definition and value

The place and transition are known as S_element and T_element, or S_meta and T_meta. $X = S \cup T$ is known as the element set of N.

The implemental rule of transition of basic Petri net is as follows: when t is given, if all $p \in t$, $M(p) \geq 1$ (M is the distribution function of Token in the place), then t is implemental, written as $M[t >]$. i.e. if any input location of transition t has one Token at least, the transition can be implemental. The implementation of transition means that the preconditions under which the event represented by transition occurs are met in the current system status.

The inherent feature of transition in the net system is: that its scope (extension) is inherent, whether the transition occurs or not depends on its extension only, regardless of the global state, which is so called local determinacy. In the net system, there is no forms of global control which can describe not only the dependency (sequencing relationship) but also independency (concurrency relationship) between events. The security and progressively of the net system have general applicability.

2.2 Basic concept of ECA rule

Definition 2.2: Active rule is a 3-tuple $\langle E, C, A \rangle$, E —event, C —condition, A —action, which has structure feature and behavior feature. When the trigger event occurs, the action is executed on basis of true or false of condition⁶. The basic denotation of ECA is as follows:

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RULE <rule name>[ (<parameters>, ...) ]
  WHEN <event>
  IF <condition 1> THEN <action 1>;
  .....
  IF <condition n> THEN <actions N>; ( $n \geq 1$ )
END-RULE [<rule name>].

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2.3 Basic Petri net model

This paper makes use of Petri net to create model, place set mainly consists of three parts: $S = SE \cup SC \cup SA \cup \text{others}$, in which SE is trigger event set, SC is condition set, SA is action set; transition set mainly consists of two parts: $T = TEC \cup TCA \cup \text{others}$, in which TEC is the trigger process of rule, by means of evaluating event, if success, then trigger rule. TCA is the evaluation process of conditions, if conditions are met, the rule will be active, then corresponding action will be executed. Since event, condition and action has atomicity which means it will occur or it will not occur at one time, the capacity of place in Petri net can be defined as 1.

For example, ECA rule is:

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on e1
if c1 then a1;
if c2 then a2.

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In this rule, it does not set coupling way between event and condition, condition and action, which can be regarded as immediate mode, in case that use Petri net to express, it can be omitted. The model is more complex regarding to simple ECA rule, but it's reasonable if the coupling relationships between E , C and A are considered.

3. PETRI NET REPRESENTATION OF COMPOUND EVENT

The event of ECA rule can be classified into primitive and compound ones. Petri net representation of compound event is researched specially in this paper.

Definition 3 compound event: the system uses requested event operators to connect several component events (atomic or compound) and handles it as a single event, which is known as compound event.

Provided that e and e' are two component events, there are several compound event definitions:

- 1) $e \wedge e'$, means compound event when e and e' concur;
- 2) $e|e'$, means that in period of occurrence there is only one compound event from e and e' , i.e. choose one occurred event;
- 3) $e \vee e'$, means there is compound event occurrence if there is only one (from e and e') compound event;
- 4) $e \bullet e'$, means that e' occurs when e is end, makes e and e' be compound event together;
- 5) $< e$, means one event that is terminated when e starts to occur;
- 6) $> e$, means one event starts to occur when e is terminated;
- 7) $\neg e$, means event that e does not occur.

Occurrence of compound event is same as atomic one, it has "atomicity", i.e., at one time, it occurs completely, or does not occur at all, there is no the 3rd state. Compound event Petri net-is as the following Fig. 1.

Fig. 1 composite events Petri net expression.

4. ECA RULE EXTENSION PETRI NET MODEL AND BEHAVIOR ANALYSIS

Execution of ECA rule is related to coupling mode, there are 2 kinds of modes: one is coupling between event and condition (E-C coupling); the other is coupling between condition and action (C-A coupling). Most active database system support the following 3 modes:

Immediate mode: when trigger event occurs (conditions are met), it executes condition decision immediately (execute action);

Deferred mode: when trigger event occurs (conditions are met), it does not execute condition decision (execute action) until "Y" of the event is terminated (execute action);

Detached mode: Condition decision (action executes) and trigger event (condition decision) run in a detached event rather than in a same one.

Due to complexity of compound event expression and complicated coupling relation of ECA rules, when modeling is made for ECA rule system, this paper puts forward a extended Petri net system on basis of Petri net principle.

Definition 4 Extended Petri net system

$$\Sigma = (S, T; F, U, V, A_{FU}, H_{FV}, M_0),$$

in which:

- 1) $(S, T; F)$ is basic net;
- 2) U is set of coupling relation, $U = \{\text{immediate, deferred, detached}\}$;
- 3) V is set of 1-tuple ordering operators: $V = \{\text{at, prev, post}\}$;
- 4) A_{FU} is $F' \rightarrow U$ binding, in which

$$F' \subseteq T_{EC} \times S_C \cup T_{CA} \times S_A, \forall f \in F', A_{FU}(f)$$

Corresponds to a kind of coupling relation;

- 5) H_{FV} is $F' \rightarrow V$ binding, in which

$$F' \subseteq S_E \times T_{EC}, \forall f \in F, H_{FV}(f) \in V$$

6) M is initial identity of Σ . Definition 3.2 ECA rule set $R = \{r_1, r_2, \dots, r_n\}$, in which $ER = \{e_1, e_2, \dots, e_m\}$ is event set of rule set R , $AR = \{a_1, a_2, \dots, a_m\}$ is action set that are executed by rule set R . Assume rule $r_i, r_j \in R$, in which $r_{ie}, r_{je} \in ER \cup OE$, OE is compound event that is formed by events in ER , $r_{ia}, r_{ja} \in AR$, when $r_{ia} = r_{je}$, it can be replaced by r_{je} .

Assume $r_1, r_2, r_3, r_4, r_5 \in R$, and expression form of such rules is:

r_1 : On $e_1 \wedge e_2$, immediate, if $r_1.c$ then e_3 , immediate

r_2 : On $e_4 \vee e_5$, deferred, if $r_2.c$ then e_6 , immediate

r_3 : On e_3 , immediate, if $r_3.c$ then $r_3.a$, immediate

r_4 : On e_6 , detached, if $r_4.c$ then $r_4.a$, immediate

r_5 : On $e_3 | e_6$, deferred, if $r_5.c$ then $r_5.a$, immediate

Taking it as an example, the corresponding ECA rule Petri net model is shown as Fig. 2:

Fig. 2 ECA rule system Petri net.

From Fig. 2, it can know about event trigger and operation procedure of ECA rule straightly, and know about trigger relation between rules. Meanwhile, it can use relevant theory of Petri net to analyze dynamic behavior of ECA rule system.

5. CONCLUSION

This paper, on basis of Petri net theory, makes modeling research on ECA rules, establishes basic Petri net model; meanwhile makes special research that how to use Petri net express compound event ECA rules; put forward extended Petri net system, and considers its feature of ECA rules in general, reflects system feature of ECA rules in all aspects. As a matter of course, This paper makes analysis on simple system action of ECA rules, it still need further research how to use Petri net technology to make analysis on system action of rules, like terminability and parallelism.

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