Alarm Reduction Processing of Advanced Nuclear Power Plant Using Data Mining and Active Database Technologies

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1. Introduction

The purpose of the Advanced Alarm Processing (AAP) is to extract only the most important and the most relevant data out of large amount of available information. It should be noted that the integrity of the knowledge base is the most critical in developing a reliable AAP. This paper proposes a new approach to an AAP by using Event-Condition-Action(ECA) rules that can be automatically triggered by an active database. Also this paper proposed a knowledge acquisition method using data mining techniques to obtain the integrity of the alarm knowledge.

2. Alarm Reduction using Active Database and Data Mining

The general structure of AAP is as follows.

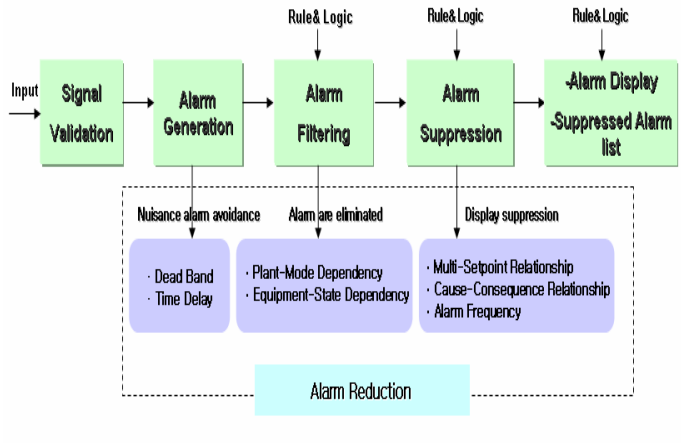

Fig.1. The structure of AAP

2.1 Active Database and Data Mining

Database management systems are at the heart of current information system technology. They provide reliable, efficient, and effective mechanisms for storing and managing large volumes of information in a advanced alarm processing. Active database technology can, therfore, enable a system to have a reactive processing and autonomous response to an event that occurs inside or outside a system. The general form of an ECA rule is illustrated in Table 1[1]. Many applications, including classical ones like an inventory control, would run much more efficiently. This would free the applications of the need to continously monitor relevant events and as result, the application code would be less complex, more manageable and reliable.

Table 1. General Form of an ECA Rule

On **Event** if **Condition** do **Action**
The **Event** of an ECA rule determines **when** the rule should be evaluated. The **Condition** of an ECA rule determines **whether** the action should be executed. The **Action** of an ECA rule determines **how** to react if the condition is evaluated as true.

Data mining is the process of finding patterns and relationships in data[2]. Data mining includes the discovery of alarm concept descriptions, a association, a classification, a prediction, a clustering, a trend analysis, deviation analysis, and a similarity analysis. Data mining will receive the alarm data from a database and establish useful active rules for the alarm reduction [3].

2.2 Adapting Active Rules for AAP

Alarm processing techniques were developed to support operators in coping with the volume of alarms, to identify which are significant, and to reduce the need for operators to infer plant conditions. This section describes the test case used to demonstrate the AAP by using the concepts of composite events.

(1) Equipment-State Dependency

The alarms activated as a consequence of an equipment-state change (e.g., pump tripped) are lowered in priority. (See table 2)

Table 2. Events Defined for an Equipment State Dependency

Event of Interest	What Triggers the event	Action to be taken
E1	Pump Trip	Trigger C1
E2	Low Flow	Trigger C1
C1	E1 and E2	Low flow alarm is eliminated

(2) Multi-Setpoint Relationship

The lower level alarms are reduced in priority when the higher level alarms also are activated. (See table 3)

Table 3. Events Defined for a Multi-Setpoint Relationship

Event of Interest	What Triggers the event	Action to be taken
E1	PZR Pressure Hi	Trigger C1
E2	PZR Press Hi-Hi	Trigger C1
C1	E2, followed by E1(sequence)	Low alarm is suppressed

(3) Cause-Consequence Relationship

A fault occurring in a certain part of the plant process propagates through the process following a cause-consequential relationship. As a result of the fault propagation, an alarm occurring in a part of the process

may cause another alarm in another part to be activated. (See table 4)

Table 4. Events Defined for a Cause-Consequence Relationship

Event of Interest	What Triggers the event	Action to be taken
E1	MFW Pump Trigger C1 Low Suction Flow	Trigger C1
E2	Heater Drain Tank Low Level	Trigger C1
C1	E2, followed by E1(sequence)	Consequence alarm is suppressed

2.3 The Process of the Detection of Event

This paper proposed an event detection process which is the most important in the whole S/W architecture of an APP using the data mining and active database techniques. The acquired alarm information is analyzed by classification rules, association rules and sequence patterns by using data mining techniques. These rules are stored in the ECA base. The models for these rules are assigned to a rule controller and are used for the basis of a determination of a signal event input. The rule execution model is based on an event detection. The steps enumerated in Fig.2 are elaborated as follows:

- When a signal (clock, application or user) causes a primitive event to trigger and the event is detected by a rule manager, a message is sent to the rule controller component.
- The corresponding condition and actions are checked against the ECA Base by the rule controller component. If there are more than two rules to be fired, the rule controller uses their priorities to decide which of the rules should be fired. The corresponding condition and action are sent to the condition evaluator and action executor components respectively. This work is done inside the rule controller component.
- If the condition is satisfied, the action is fired by the action executor.
- After the action execution, the composite event detector will be invoked to check of this event can cause any composite events to trigger. This is done by the rule controller component

2.4 Design Considerations of Active Database Systems for the APP

This section describes the design considerations of the ADS(Active Database System) for the AAP, and it also describes the solution plan against each consideration. (See table 5)

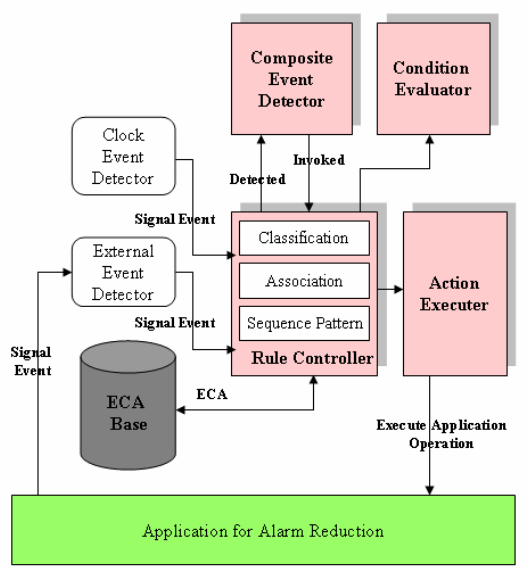

Fig.2. Process of the Detection of Event

Table 5. Design Considerations and the Solutions

Considerations	Solutions
Rule Modeling	-Acquiring of operation data for NPP simulator -Analysis classification, association, clustering and sequence pattern
Rule V&V	IDEA methodology
Primitive Event	Time, external event
Composite Event	Conjunction, disjunction, sequence, negation, times,
E-C Coupling	Independent mode
C-A Coupling	Independent mode
Execution Model	TMO based Micro-kernel
Rule Termination	Triggering graph
Recursive Rule	No recursive rule execution

3. Conclusions

This paper proposed a new approach to an advanced alarm processing by using Event-Condition-Action(ECA) rules that can be automatically triggered by an active database and a knowledge acquisition method using data mining techniques to obtain the integrity of an alarm knowledge. Also this paper proposed of design considerations and solutions of ADS for AAP the S/W structure for process of the detection of event. We will implement and test a prototype for ADS for AAP that captures the main elements of the ADS for the AAP in the future.

REFERENCES

[1] C.W.Tan, A.GOH, “Implementing ECA Rules in an Active Database, Knowledge-Based Systems”, 12, 137-144. 1999

[2] Pang-ning Tan, “Introduction to Data Mining”, Addison Wesley, 2007

[3] Jiawei Han, “Data Mining: Concepts and Techniques”, Morgan Kaufmann Publishers, 2001