Creating Operation Method Patterns for Automating Information System Operations

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Abstract: - The authors propose operation patterns based upon analysis of operations conducted in data centers for system management. The feasibility of the automated operations is analyzed for each pattern. The correlations between operation patterns and the objectives of operations are also analyzed.

Key-Words: - system management, workflow, patterns, automation, autonomous computing

1 Introduction
Automation of operations is effective for reducing information system management cost. Although automation tools for system management have been proposed [1] [2] [3] [4] and some products have appeared on the market, the level of automation in actual data centers is not sufficient. A lack of established design methodologies suitable for automated system management and operation is one of the reasons for this situation. As the first step towards establishing methodologies, the authors propose a model for system management operations and patterns for operations based on analysis of operations in an actual information system.

2 Model of system management operations

2.1 Management activities of information systems
Management of information systems consists of coordinated activities to make the system maintain provision of the aimed functionalities at a satisfactory service level. Usually, the following activities are included:
(1) Invocation, termination, partial termination, and restart of the entire system or components of the system.
(2) Configuration changes and update of the system and its components.
(3) Monitoring activities to make sure that the entire system and its components work normally.
(4) Collection and evaluation of metrics information to inspect the condition of the entire system and its components.
(5) Responses to malfunctions in the entire system and its components.
(6) Backup of data preparing for system failures.

These activities are considered in the design of system management and finally defined as a list of management operations. In some cases, a list of these operations is provided as an operation manual referenced by operators. In other cases, a part of the list is provided in an executable format such as shell scripts or scripts for automation tools.
2.2 Model of operations

Operations described above can be defined as workflows regardless of whether they are executed manually or automatically by tools. In this paper, operations are modeled as follows:

(1) An operation is described as a directed acyclic graph (DAG). The direction of an arc between nodes indicates the order of execution between work units denoted by nodes.
(2) A work unit is categorized in one of four categories as follows:
   - Event Detection (E): Detection of a change in status which invokes an operation
   - Condition Check (C): Checking condition of the object related to the operation
   - Judgment (J): Selection of a subsequent unit of work based upon results of a condition check
   - Action (A): Actions to be taken on the object of the operation
(3) The following restriction is applied to the configuration of the graph:
   - (a) The root of the graph must be a single Event Detection node.
   - (b) The leaves of the graph must be Action nodes.
   - (c) For every Judgment node there must exist at least one incoming arc from a Condition Check node.
   - (d) Targets of arcs starting from a Judgment node must be an Action node or Condition Check node.

An example of a graph representing an operation by this definition is shown in Fig.1.

2.3 Detailed categorization of work unit

Management operations can be considered as a workflow. The Workflow Patterns Initiative collects patterns of workflows [5]. This pattern collection focuses on the control flow patterns. To automate operations, you must consider whether the work units can be automated. Therefore, for extracting patterns of management operations, in addition to the control flow, categories of work units should be considered.

Work units can be divided into two categories; Event Detection and Action.

(1) Event Detection:
   - Timer monitoring: The operation is invoked when a predetermined time is reached.
   - Active manual operation: The operation is invoked by an active manual operation by an operator.
   - Event monitoring: The operation is invoked when a predefined event occurs.

(2) Action:
   - Notification: Reporting abnormal situation of the system to operators by means of sending an e-mail, buzzer, lamp etc.
   - Data manipulation: Performing backup, storage or deletion of predefined data for recovering to a previous status, investigation of causes, or preventing further damage to the system.
   - Recovering action: Performing action to recover the system to the normal status.

3 Extracting operation patterns from existing operations

3.1 Description of surveyed systems

Table 1 shows a list of systems surveyed to extract operation patterns.

Case 1 and Case 2 are both systems providing public service via the Internet and actual operation manuals were analyzed. Case 3 and Case 4 are not systems in service but model operation manuals, which are provided by a vendor of J2EE application server and electronic document workflow system as collections of best practices using system management functionalities supported by the products.

All of surveyed systems are J2EE based web application systems and consist of multiple servers.

E: Event Detection, C: Condition Check, J: Judgment, A: Action

Fig. 1: A Sample Operation
Table 1: List of Analyzed Systems

<table>
<thead>
<tr>
<th>Case</th>
<th>System Description</th>
<th>Web Server</th>
<th>AP Server</th>
<th>DB Server</th>
<th>Number of Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case1</td>
<td>Shopping site</td>
<td>14</td>
<td>4</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>Case2</td>
<td>Photo upload site</td>
<td>3</td>
<td></td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Case3</td>
<td>J2EE base Web system</td>
<td>Web 5–tires</td>
<td></td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Case4</td>
<td>J2EE base Electronic Form Workflow system</td>
<td>Web/AP/DB</td>
<td></td>
<td></td>
<td>47</td>
</tr>
</tbody>
</table>

These systems are examples of current trends in information systems and, in these systems, rigid management is inescapable to keep the system reliable and efficient. As mentioned above, the systems in Case 1 and Case 2 provide services to the public via the Internet. Therefore system failure may cause a huge impact on the business of the service providers. In addition to basic operations such as invocation and termination of systems and backup of data, the operation manuals for these two systems describe operations for version updating of an application, updating for security, reaction to spikes in access, and recovery from system failure. The model operation manuals surveyed in Case 3 and Case 4 contain detailed descriptions of operations for invocation and termination, backup of data, version upgrading of applications, and reaction to system failures using functionalities supported by the products.

3.2 Extracted patterns

By analyzing the four cases mentioned above, four patterns and six sub-patterns were extracted. Table 2 shows the extracted patterns.

Descriptions of each pattern are given below.

(1) Pattern-1: Periodic Customary Operation

This pattern is used for performing an action like invocation, termination, restart and data manipulation in a periodic manner.

An event graph representation of the Periodic Customary Operation pattern is shown in Fig. 2. The description below the work unit indicates the detailed category given in section 2.3.

From the viewpoint of automation, operations of this pattern are often already automated. Even if an operation is currently operated manually, it is easy to automate the operations in this pattern if the action to be taken can be implemented with software and without intervention by a human operator.

(2) Pattern-2: Non-periodic Customary Operation

This pattern is used for operations that are customary but not periodic because they can be performed at any time when a certain condition is satisfied or should be performed after completion of another operation for which the termination timing is uncertain. The operations of the Without Condition Check pattern (pattern 2-1) are invoked when monitored events are detected or an operator performs active manual operations. For operations of the With Condition Check pattern (pattern 2-2), prerequisites for performing an Action are checked before performing an Action by the Condition Check work unit and if the prerequisite is not satisfied, the fact is reported to an operator by performing the Action of Notification.

A graph representation of the Non-periodic Customary Operation pattern is shown in Fig. 3.

The major difference between Pattern-1 and Pattern-2 is the way the operation starts.

In terms of automation, if a category of the Event Detection work unit is an active manual operation, due to the necessity of human intervention, it cannot be automated. If the category of Event Detection is event monitoring and events can be monitored by software, the Event Detection work unit can be automated. The possibility of the whole operation being automated depends on whether the Condition Check and Action work unit can be implemented with software only and without human intervention.
Pattern 2-1: Non-Periodic Customary Operation (Without Condition Check)

Event monitoring/
Active manual operation
Data manipulation/
Recovering action

Pattern 2-2: Non-Periodic Customary Operation (With Condition Check)

Event monitoring/
Active manual operation
Checking prerequisite
for Action
Recovering Action/
Data manipulation

Notification/Recovering Action

Fig. 3. Pattern 2 Non-periodic Customary Operation

(3) Pattern 3: Notification
This pattern is used for operations that report the change in the status of a monitored object to an operator to make the operator perform the appropriate action if necessary.

The Without Condition Check (Pattern 3-1) pattern is applied when an object is monitored all the time by an Event Detection work unit and a change of status in a monitored object is reported to an operator by means such as sending an e-mail, sounding a buzzer, or lighting up a lamp. The Operations With Condition Check pattern (Pattern 3-2) is invoked by Event Monitoring or Active manual operation and the Condition Check unit work is performed to check the condition of the monitored object. If a problem is detected, the Notification Action is performed; otherwise no action is taken.

The difference between Pattern 3-1 and Pattern 3-2 is

Pattern 3-1: Notification (Without Condition Check)

Event monitoring
Notification

Pattern 3-2: Notification (With Condition Check)

Event monitoring/
Active manual operation
Check status
normal
abnormal
Notification

normal

Fig. 4: Pattern 3 Notification

Pattern 4: Error recovery

Event monitoring
Checking prerequisite
for actions
NG
Recovery action/
Data manipulation

OK
A
A

Notification

Fig. 5: Pattern 4 Error Recovery

the monitored object is always under surveillance (Pattern 3-1) or checked only when some condition is satisfied (Pattern 3-2).

A graph representation of this pattern is shown in Fig. 4.

(4) Pattern 4: Error recovery
This pattern is used for operations for recovering from system failures. An operation of this pattern is invoked upon a status change of a monitored object and after checking prerequisites of Action work units.

A graph representation of this pattern is shown in Fig. 5.

Automation of an operation of this pattern depends upon whether work units contained in the operation can be implemented as software without human intervention.

4 Correlation between operation patterns and operation objectives

4.1 Operation objectives
There are three major objectives of system management operations as follows:

(1) Regular operation: operations performed regularly in normal situation

(2) Maintenance operation: operations performed upon maintenance such as system configuration changes and upgrade or version update of hardware or software.

(3) Emergency operation: operations performed upon a failure or when a symptom of a failure is detected.

4.2 Correlation between operation patterns and operation objectives
The result of the analysis of the correlation between operation patterns and operation objectives is shown in Table 3.
The Periodic Customary Operation pattern (Pattern 1) is used for regular operation. The Non-periodic Customary Operation pattern (Pattern 2) is used for either regular operation or maintenance operation. The result reflects the fact that maintenance operations are performed not periodically but at the time of an event like software version upgrading.

As for the Notification pattern (Pattern 3), Without Condition Check pattern (Pattern 3-1) is used for an emergency operation. The Condition Check pattern (Pattern 3-2) is mostly used for maintenance operation. The reason of the difference is that the Without Condition Check pattern (Pattern 3-1) is often used for reporting a problem found by monitoring a managed object all the time, and the With Condition Check pattern (Pattern 3-2) is often used for checking the result of a preceding operation in a sequence of operations for maintenance work such as software version upgrading. There are some cases that Condition Check pattern (Pattern 3-2) is used for regular and emergency operation.

The Error Recovery pattern (Pattern 4) is used for emergency operations. Operations of the Error Recovery are used for recovering from condition detected as inappropriate. Therefore those are used for emergency operation.

5. Conclusion
In this paper, the authors propose operation patterns extracted by analyzing existing system management operations. Also, the correlation between operation patterns and operation objectives is described. Study of patterns of work units is to be done as a next step of research towards an effective design methodology for automated system management.

The operation patterns proposed in this paper can be used as a guideline for reviewing existing system management operations towards automated management.

Another possibility of the application of operation patterns described in this paper is a pattern based on wizard functionality of a design tool for system management operations. The wizard functionality is beneficial for improving the efficiency and correctness of design of system management operations.

References:

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