Generating and Checking Technique for D5000 Alarm Information

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Abstract. To solve the problems of vague description, undefined interval and a lack of alarming level existing in D5000 alarm information, this paper proposed an information generating and checking technique using semantic analysis. The generating function of D5000 alarm information table was realized with the theory of expert knowledge base for reference. Besides, the checking and error-correcting function was accomplished through character decomposition and extraction. Results of applying the method in practical case shows that the method is valuable in following aspects: simplifying the manual checking process, improving the information processing efficiency, optimizing the management level of alarm information, and so on.

Introduction

Smart Grid Dispatching and Control Systems (hereinafter referred to as D5000 systems) were launched by National Electric Power Dispatching Center in February 2008. Including the foundation platform of integrated technical support system and advanced application functions [1], D5000 systems are standardized, open, reliable, safe, strong and adaptable, which improve the operation level, standardization construction and intensive management of power grid dispatching. With the use of D5000 systems, the corresponding specification and requirements of alarm information management are also proposed under the regulation and control integration mode [2,4]. In the traditional ON2000 systems, it mainly consist the following problems [5]:

(1) The description and definition of alarm information are not exact.
(2) The interval of alarm information cannot be reflected.
(3) There is no alarm classification to meet the monitoring requirements.
(4) The alarm information is too detailed and complicated.

This paper established a practical technique of generating and checking D5000 alarm information based on the expert system theory and semantic analysis [6,10]. Combined with the file "Typical Monitoring Information Table for 110kV Substation and below (Trial)", the standard alarm information templates were prepared, which could be called by the program to generate D5000 alarm information tables. Then comparative analysis and checking were accomplished between ON2000 and D5000 alarm information tables, automatically extracting the logical variables through character decomposition. The method statistically matches the whole information and output the problem points, which effectively helps monitor the equipment status and ensure the operation safety of power grid. Also it improves the processing efficiency of alarm information.

Basic Thought and Procedure

Alarm information is designed for human analysis. When standardizing D5000 alarm information tables, the manual selection and error correction are often needed. It obviously increases the workload of the monitoring people and the difficulty of information processing. Therefore, it is necessary to study the definition and description rules of alarm information to establish effective checking model and simplify the manual process.

The data format of alarm information mainly includes the code identification and alarm name, while the code identification is commonly used in information retrieval and the alarm name is used to
describe the event information. Generally, the alarm name is defined with certain regularity. So it can be decomposed into several independent key fields by semantic analysis method. By comparing the key fields one by one, the checking and error-correcting function could be realized.

The generation and verification technique for D5000 alarm information are mainly based on the file "Typical Monitoring Information Table for 110kV Substation and below (Trial)", which is provided by State Grid Corporation. According to the file requirements, the information interval, alarm classification and voltage level should be taken into consideration when dealing with D5000 alarm information. The basic thought and procedure of alarm information generating and checking are shown in Fig 1.

![Figure 1. Flow diagram of alarm information generating and checking.](image)

**Standardized Template Generation of Alarm Information**

The expert system is a method simulating subject matter experts (abbreviated as SME) to solve the professional problems, which converts SMEs’ knowledge into procedural machine language to judge and analyze the problems with computer strategy.

Under the integration mode of regulation and control, substation-monitoring mode is changed from decentralized analysis to centralized monitoring. The traditional manual analysis cannot solve the problem of inefficiency and security risk caused by the surge of alarm information. For district dispatching centers, the substation monitoring information may amount to ten thousand or even hundred thousands, which follows some certain principle and clues. Therefore, the standardization of similar information has universal significance.

Based on the expert system theory, this paper established the alarm information knowledge base system, classifying and standardizing the alarm information. This work helps effectively simplify the information content of the knowledge base system and also optimize the processing mechanism and management level of alarm information.

Sub-module number statistics and template preparation should be done according to electrical equipment types, including main transformer, line, bus tie switch, capacitor and common equipment. In order to manage the alarm information more efficiently, the templates should contain the respective interval, alarm classification and voltage level. With the call-module program, sub-module templates could be called to automatically generate D5000 alarm information tables.
Take the capacitor as an example. First of all, determine the type of electrical equipment, if the type is "capacitor", call the "capacitor" module program and automatically add the "capacitor" template to D5000 alarm information table. The equipment number "XX" is input from the visual interface. Specific call-module program is shown in Table 1.

Table 1. Call module code of information template.

```
Sub Capacitor()
    Sheets("Capacitor ").Select
    Range("A2:A23").Select
    Selection.Copy
    Sheets("Generate Tables").Select
    Range("A65536").Select
    Selection.End(xlUp).Select
    ActiveCell.Offset(1).Select
    ActiveSheet.Paste
    Cells.Select
    Selection.Replace What:="XX", Replacement:=
    Sheets("Application Interface").Cells(8, 3), LookAt:=
    xlPart, _SearchOrder:=xlByRows, MatchCase:=False,
    SearchFormat:=False, _ReplaceFormat:=False
    Sheets("Application Interface ").Select
```

Alarm Information Checking Based on Semantic Analysis

In order to get the basic logic variables to check alarm information, all the information should be analyzed according to the following quintuple structure:

\[
T = \{S\}, \{D, O, A, B\} \\
S = \{I, C, V\}
\]  \hspace{1cm} (1)

The meaning of the symbols in formula (1) is as follows: \{S\} is the scene in which alarm information can be parsed as an embedded triplet. \(I\) is the interval name, \(C\) is the alarm classification and \(V\) is the voltage level. Triplet \{S\} can be used as searching conditions in the alarm information analysis, which helps simplify the traversal range of information checking [11,12].

\(D\) is the electrical equipment name, which are the subject of the event and the object of analysis.

\(O\) is the secondary equipment, including protection category \(O_p\), circuit breaker category \(O_k\), reclosing category \(O_r\) and common category \(O_g\). \(O\) is mainly used to describe the specific secondary equipment, which can give an alarm for electric equipment faults.

\(A\) is the action attribute of protection category \(O_p\), which reflect different circles and importance of protection action.

\(B\) is the specific action behavior corresponding to the secondary equipment, which express the specific content of alarm event and the action seriousness.

In order to obtain the key variables of single alarm information, this paper adopted the improved pattern-matching algorithm of BM to orderly match the alarm information text and semantic analysis model [13,14]. Specific flow of sequential maximum matching is shown in Figure 2.

![Figure 2. Flow diagram of sequential maximum matching.](image-url)
The analysis and checking process of single alarm information can be divided into two steps: (1) Match the key character sequence with the semantic analysis model to determine whether the alarm information contains the logical variables or not; (2) According to triplet \( \{S\} \), traverse the grouping alarm information and classifiably output the problem points by contrasting alarm information of D5000 and ON2000 systems [15,16]. After the information matching, the residual character threshold should be considered, where the remaining string length should not exceed 4 characters or two Chinese characters, or the matching fails.

When traversing the alarm information of D5000 and ON2000 tables, the information under the same scene \( \{S\} \) is artificially defined as a group and given a group identifier \( \text{Flag} = \{\text{flag}_j\}_{1 \leq j \leq N_g} \), which contains the \( \{S\} \) information and helps effectively reduce the traversal range and save checking time.

**Checking Flow and Case Analysis**

The checking program can accomplish the semantic analysis of all the alarm information in D5000 and ON2000 systems in the first run. Through the group identifier \( \text{Flag} \), traversing and matching work of D5000 and ON2000 tables could be realized. Besides, Matching Degree of alarm information can also be also calculated as follows: Matching degree = \( \text{Total number of successful matches of remote communication} \div \text{D5000 Total number of templates information} \times 100\% \). Finally, the problem points could be output to help monitoring people do the further artificial checking.

This paper just took the alarm information checking application of some 110kV substation as an example. By inputting all the equipment statistics into the visual interface, D5000 alarm information table is generated. The information amount totals 1057 while that in ON2000 table totals only 798. Analysis shows that ON2000 table seriously lacks the alarm information. Further analysis and matching is needed to find out the problem points.

In order to compare D5000 template table with ON2000 information table, D5000 and ON2000 tables should be both imported into the checking program. The final matching results could be obtained through semantic analysis and grouping traversal program. Table 2 only listed partial problem points corresponding to the scene \( \{S\} \), where the interval is 1# main transformer, the alarm classification is abnormity and the voltage level is 110kV.

<table>
<thead>
<tr>
<th>Alarm information having problems</th>
<th>Problem points analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1# main transformer monitoring and control device communication interrupted</td>
<td>The information of ON2000 and D5000 tables are not exactly the same.</td>
</tr>
<tr>
<td>1# main transformer Protection A device abnormity</td>
<td>There is no corresponding alarm information in ON2000 table.</td>
</tr>
<tr>
<td>1# main transformer Protection A device fault</td>
<td>There is no corresponding alarm information in ON2000 table.</td>
</tr>
<tr>
<td>1# main transformer Protection B device abnormity</td>
<td>There is no corresponding alarm information in ON2000 table.</td>
</tr>
<tr>
<td>1# main transformer Protection B device fault</td>
<td>There is no corresponding alarm information in ON2000 table.</td>
</tr>
<tr>
<td>1# main transformer 101 breaker trip/closing pressure low</td>
<td>There is no corresponding alarm information in D5000 template table.</td>
</tr>
</tbody>
</table>

The results showed that the amount of successfully matching information between D5000 and ON2000 information tables totaled 523, with which the matching degree was calculated as 49.48%. That is to say, the matched information only accounted for about half.

From the data, it is obviously seen that there are mainly three types of problems: a lack of alarm information, alarm information redundancy and vague description of alarm information. The number corresponding to the problem points are 368, 109 and 166. Besides, a lack of alarm information is the most urgent problem in great need of solving. During the D5000 system on-line process, the deficient information should be added to D5000 alarm information table after consulting the substation staff.
Summary
This paper presented a technique of generating and checking D5000 alarm information using semantic analysis and expert system theory, which can be widely used to check and standardize alarm information for district dispatching centers. It is a new thought to improve the alarm information management. The application of substation case shows that the method is advanced and valuable in solving the problems of vague information description, a lack of alarm information and information redundancy in D5000 systems. Through the keyword-matching algorithm, the problem points could be also selected and manually modified, which helps monitoring people save the artificial checking information time, enhance the quality of alarm information processing and optimize the management level of alarm information.

References