Design of satellite ground fault diagnosis system based on rule base

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Abstract. The automation and intelligentization of fault diagnosis system for satellite ground system directly affect the success of tasks and the reliability of the system. This paper designed a fault diagnosis system based on rule base, which contained satellite ground system failure rule base, failure model, abnormal and alarm mechanism. Software implementation has been verified by actual project, it shows that the fault diagnosis system based on rule base can improve the capacity of fault management functions, real-time monitoring and automatic fault diagnosis support system. In addition, fault analysis and location can enhance the automation level and efficiency of satellite fault diagnosis, make efficient and reliable diagnosis of remote sensing satellite receiving system, raise the success rate of satellite data receiving, and have good practicability and popularization.

Keywords: Satellite ground system, Rule base, Fault diagnosis.

1 Introduction

In recent years, China's space infrastructure has been increasingly improved, and the number of satellite launches has increased year by year. As the core part of the whole link, the ground system contains a wide variety of devices, and the devices in the system are tightly coupled. Any single point of failure may lead to the system cannot work properly, and then affect the quality of satellite data transmission. At the same time, the current receiving ground station to deal with the system fault largely depends on manual participation, resulting in the system fault location is not accurate, troubleshooting time is long, ineffective maintenance.

For complex ground system equipment, measurement and control and data transmission, communication link management, task flow, etc., all kinds of fault monitoring and diagnosis is particularly important. The automation and intelligentization of fault diagnosis system directly affect the success of tasks and the reliability of the system.

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2 System design

2.1 Overall design

The core of fault management design is rule base, which is the key link of fault management. It contains a lot of facts and rules in the field. The organization design of the rule base directly affects the efficiency of the whole fault management. In this paper, the fault tree model is used to express the complex rules, and the rule storage mode is basically consistent with the real manual diagnosis. Figure 1 shows fault management design diagram.

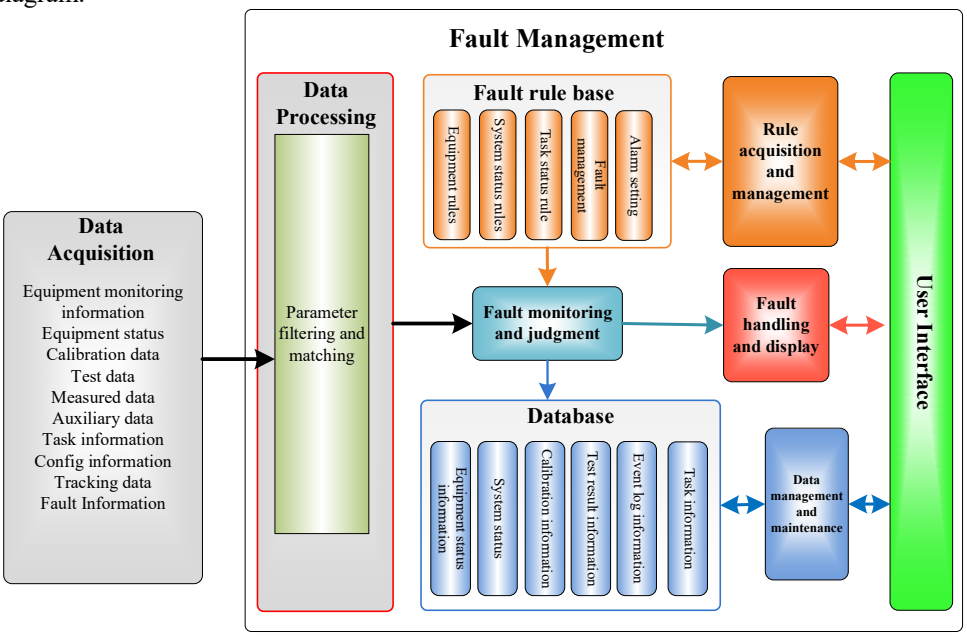

Fig. 1. Fault management design diagram.

2.2 Rule base design

2.2.1 Obtaining rules

Rules can be obtained in three ways:

Obtain rules from domain experts

This is the most straightforward and easiest way to get the rules. Developers through contact and talking with field experts, extracts theory and case knowledge, and then stores it in the rule base with the agreed coding way.

Obtain rules by editing the software.

In this approach, domain experts enter empirical knowledge into the rule base by interacting at the software interface.

Obtain rules by updating the rule base.

Rule base has the reusability and extensibility, rule base is a separate database entity, that can import and export expediently, and combined with other ground rules of fault

structure, it can be applied to a lot of different satellite ground station. The fault rule base station can update at the same time, using the total station network knowledge.

2.2.2 Rule base structure

The core function of the ground station is to complete the satellite data two-way transmission. For such complex problem, the idea of programming decomposition is adopted to decompose it into simpler sub-problems for solving, and then coordinate the answers obtained. It is various and complex for the equipment involved in satellite measuring and control and data transmission. According to the requirements of fault management and diagnosis object as shown in figure 2, the faulty knowledge is classified and organized to construct the knowledge classification system.

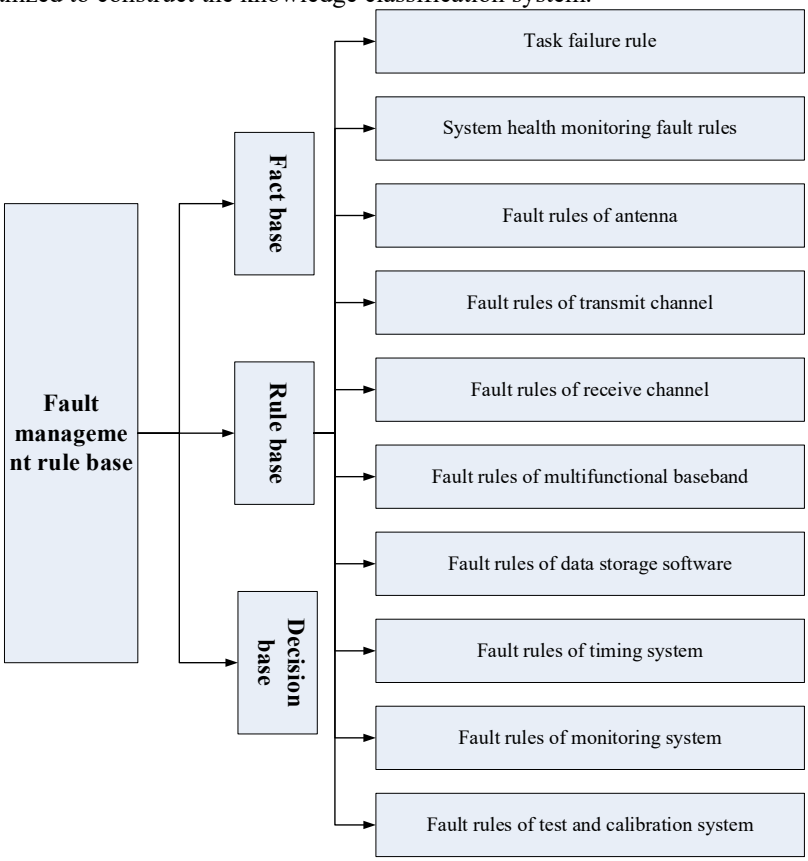

Fig. 2. Fault management fault rule knowledge base structure.

Fault management rule base consists of the fact base, rule base, and decision base.

The fact base mainly stores factual knowledge, including attributes extracted from collection rules, judgment conditions and other atomic items, such as the status of data transmission, measurement and control test task and the conclusion of the status.

The rule base mainly stores the rules used in reasoning, the premise part of rules and the conclusion part of the rules. It is composed of three tables, rule prerequisite table, rule conclusion table and rule table.

The decision base stores maintenance suggestions, it can provide plans for fault and alarm after determining fault types and analyzing fault causes.

2.2.3 Rule base maintenance

The rule base is an independent entity that stores knowledge, which is needed to be extracted and managed programmatically. The fault management rule base is constantly updated and can be shared across the entire ground network. Therefore, the software uses graphs and lists to manage and maintain all kinds of facts and rules of fault management, including query, browse, add, modify, delete and other functions.

In the rule base, the operation of the fact base, rule base and decision base is carried out uniformly through the user interface. The updating of the rule base should follow certain constraint rules. In addition to the common database constraint rules, there should also be the following constraints:

Fact base: Records cannot be empty and any two records cannot be the same.

Rule base: The conditional fact number and the conclusion fact number of any record cannot be the same. Any two records cannot be mutually conditional and conclusion; For a new rule, the preconditions must exist in the rule base preconditions and the conclusion must exist in the rule base conclusion.

With the operation of the system and the extension of fault rules, new knowledge will be continuously added into the rule base, and the number of rules is also increasing. Although some consistency control is carried out in the operation of the rule base, there are still contradictions, redundancy and inconsistencies and incompleteness among rules.

Rule base consistency check includes: knowledge contradiction, knowledge cycle, knowledge equivalence, knowledge implication and knowledge imperfection. Knowledge contradiction refers to two contrary conclusions from the same antecedent or two contradictory conclusions from the same premise. Knowledge cycle refers to a loop chain formed by rules. Knowledge equivalence means that if the antecedents of two rules R1 and R2 are equivalent, the conclusions are also equivalent. Knowledge implication means that if the conclusions of two rules R1 and R2 are equivalent, but the antecedent of one rule R1 contains the antecedent of another rule R2. Knowledge incompleteness is when the facts in the fact base are not fully included in all the antecedents and antecedents of the rules in the rule base.

In addition, according to the features of the fault management rules, it needs to perform the following checks:

Generally, there is only one element for the foregoing rule, and it is a non-leaf fact.

The hierarchical structure of the fault tree is clear, and fault trees are independent from each other, there has no crossing.

Any fact is at most a foregoing rule and an after-factor to a rule.

3 Implementation and verification

According to the above design ideas, this paper completed the development and implementation of remote sensing satellite receiving system fault diagnosis system. According to the state information of receiving system collected in real time, the system makes use of the existing expert knowledge in the rule base to diagnose. When a fault occurs, it prompts maintenance suggestions based on expert knowledge in real time. The receiving workflow diagnosis is shown in figure 3, and the rule base of fault diagnosis is shown in figure 4.

4 Conclusion

In this paper, a design scheme of satellite ground fault diagnosis system based on the rule base is described. The fault rule base, fault model, anomaly and alarm of satellite ground

system is designed, and the software implementation is shown. This scheme has certain rules of fault management functions, support system for real-time monitoring and automatic fault diagnosis, and carry out the artificial fault analysis of positioning after the event, it can improve the automation level and efficiency of satellite fault diagnosis system, the remote sensing satellite receiving system work efficiency and reliable fault diagnosis, Improving the success rate of receiving satellite data. The promotion of this scheme is of great significance.

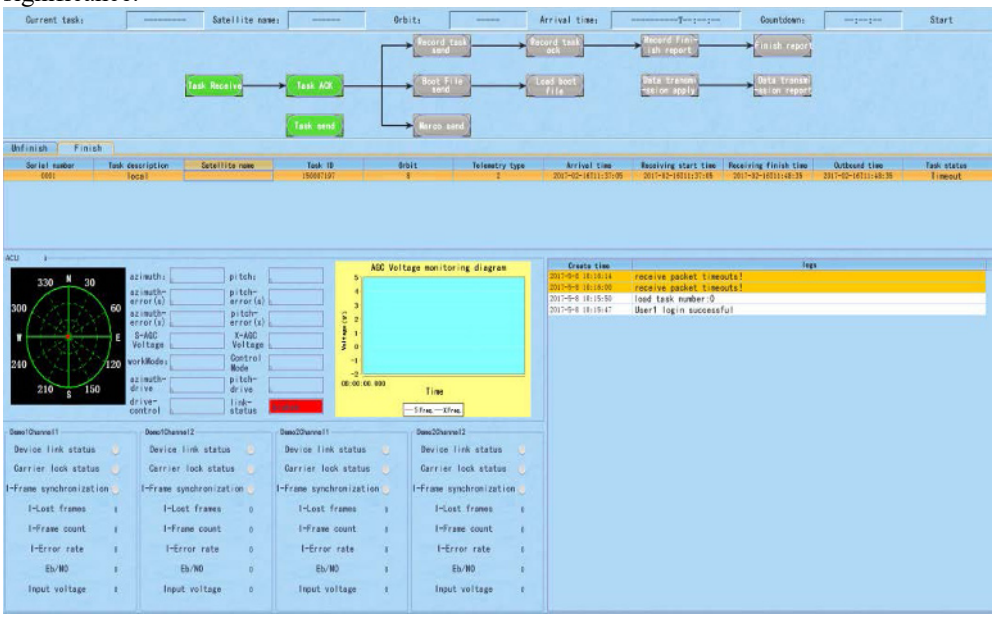

Fig. 3. Receiving workflow process diagnosis.

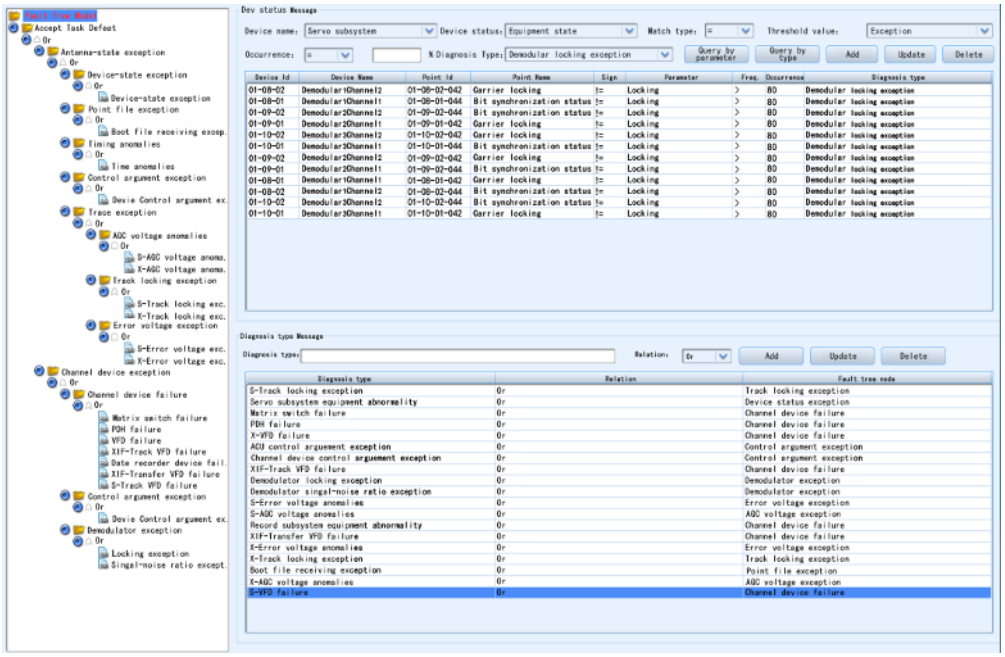

Fig. 4. Rule bases of receiver fault diagnosis.

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