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Research on Reconfiguration Time Analysis Method of Integrated Modular Avionics System

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Abstract: - The fault-tolerant reconstruction of the integrated modular avionics system electronic system can effectively improve the reliability of the system and ensure the normal operation of system functions. Accurate analysis of the reconstruction time of the integrated modular avionics system is helpful to evaluate the rationality of the reconstruction blueprint and the reliability of the reconfigurable integrated modular avionics system. Based on the in-depth study of the integrated modular avionics system architecture, software and hardware configuration, and system reconstruction process, this paper analyzes the system reconstruction time of different reconstruction modes in view of the uncertainty and diversity of the system reconstruction leading to the complex system state. According to the basic concepts and characteristics of the integrated electronic system, the integrated electronic system model is summarized and designed. Propose an application migration optimization algorithm for system reconfiguration. Based on the integrated electronic system model, build an integrated modular avionics system reconstruction verification platform. Using the reconstruction verification platform, the proposed reconfigurable integrated electronic system framework and model are used for experimental verification.
Keywords: - integrated modular avionics system, reconfiguration, time analysis, system verification

I. INTRODUCTION

With the continuous expansion and complexity of the integrated modular avionics system, the integrated electronic system accounts for more and more of the research and development cost of the switchboard. Integrated Modular Avionics System reconstruction is the process of reconfiguring system resources and loading application software to ensure normal operation of the system under the influence of system operating environment or resource failure[1]. Due to the diversity and uncertainty in the logic mapping of the integrated modular avionics system , it has been Become an important aspect of integrated electronic system research that how to integrate system resources, improve the flexibility of the system architecture and the utilization of system resources, while meeting the requirements of system reliability and safety, and ensuring that the system's normal reconstruction[2].

At present, the system blueprint is an important means to realize the reconstruction. The system blueprint is a system configuration descriptive document that manages and controls system resources and ensures that hardware resources meet the system software configuration. System reconfiguration can be realized by generating and invoking system blueprints under different fault states[3].

This paper provides a theoretical basis for the analysis of reconstruction time by modeling the integrated modular avionics system, system reconstruction modeling and reconstruction time modeling. By studying the integrated modular avionics system architecture[4], reconstruction strategy and reconstruction process, a reconfigurable integrated electronic system platform is built, and the reconstruction time of the integrated electronic system is theoretically analyzed and experimentally verified based on the theoretical foundation and reconstruction verification platform[5].

The remaining part of the paper mainly contains the following contents: Section II mainly model the integrated electronic system. Section III mainly build an integrated modular avionics system reconstruction verification platform and test it. Section IV makes a conclusion.

II. SYSTEM MODELING

Firstly, the software and hardware of the integrated modular avionics system are modeled, and the configuration model of the software on the system hardware is described. The fault model and reconstruction model of the system are constructed, and the fault type of the system and the system reconstruction triggered by the fault are analyzed on this basis. Finally, a reconstruction time model is established, which lays a theoretical foundation for reconstruction time analysis.

2.1 The model of the integrated modular avionics system

The integrated modular avionics system consists of two parts: the hardware of the system and the software of the system. The hardware of the system includes the on-board processor, various functional boards, sensors and other loads. The hardware and the software of the system are deployed through related configurations. In order to realize a reconfigurable integrated modular avionics system, the system is generally equipped with multiple processors, and each processor core is assigned different applications[6]. Multiple cores can process multiple applications in parallel, realizing a multi-core parallel processing mechanism.

2.2 The model of the system reconfiguration

2.2.1 The model of the system failure

For integrated modular avionics system[7], the possible types of failures include processor core failure and processor failure. The failure of processor C_i is expressed as F_i, the core C_iP_{ij} failure of processor C_i is expressed as, and the system failure can be defined as the following expression:

$$Fault \in F_i \cup F_{ij} \tag{1}$$

In which $Fault$ indicates a failure of the integrated modular avionics system. $F_{ij} \in (F(C_iP_{i1}), F(C_iP_{i2}), \ldots, F(C_iP_{in}))(i = 1, 2, \ldots, m)$ represents the failure set of the core P_{ij} of the processor C_i; $F_i \in ((F(C_1), F(C_2), \ldots, F(C_m))$ Represents the failure set of processor C_i, and $F_i \cup F_{ij}$ represents the possible failure set of the integrated electronic system.

2.2.2 The model of Refactor migration

The reconfiguration migration model of the integrated modular avionics system indicates that the system migrates from the operating state of one configuration to the operating state of another configuration triggered by a fault. It can be defined by:

$$RC_i = SC_j \overset{Fault}{\Rightarrow} SC_k \tag{2}$$

In the formula, RC_i represents the blueprint of system reconstruction; SC_j indicates the operating status before the system failure; SC_k represents the operating state that the system enters after the failure occurs.

2.2.3 The model of Time reconstruction

The main object of integrated modular avionics system reconstruction migration is application migration[8]. The deployment and migration process of the application in the integrated electronic system will trigger different migration actions, and the occurrence of these actions causes the time delay of the reconstruction. It includes four basic actions in the application migration process: application cancellation, application loading, application binding, and state synchronization.

When a core in a processor fails, other cores of the processor can assume the operation of applications on the failed core[9]. Applications in the processor share a storage space, and it includes application cancellation and application binding in migration actions.The inter-core reconstruction time model is expressed as:

$$t_{EL} = t(A_R) + t(A_B) \tag{3}$$

In the formula, $t(A_R) = t(A_R(App_i, C_iP_{ij}))$ indicates the time when the application revocation occurred. And $t(A_B) = t(A_B(App_i, C_iP_{ik}))$ represents the time when the application binding is generated.The inter-processor reconfiguration of the integrated electronic system will be triggered when a processor in the integrated modular avionics system has a major failure and the application deployed on the processor needs to be migrated to other processors.Since each processor has its own separate storage unit, the data generated by the application running between the processors are independent of each other[10]. The migration actions generated during the migration process include application cancellation, application loading, application binding, and state synchronization.

III. RECONSTRUCTION VERIFICATION PLATFORM AND TEST

The reconstruction of the integrated modular avionics system is mainly the process of redeploying the tasks and functions running in the system.The reconstruction of the integrated modular avionics system is mainly the process of redeploying the tasks and functions running in the system.In order to verify the impact of the reconfiguration process on the operation of the system, a reconfigurable integrated electronic system platform needs to be built. By deploying applications and tasks on the reconstruction verification platform, and simulating failures during system operation, the time consumed in the system reconstruction process caused by the failure is calculated, and the safety and reliability of the reconstruction process are analyzed.

The overall system architecture consists of two parts, namely the integrated modular avionics system and the reconfiguration management and monitoring system.The integrated modular avionics system is composed of an integrated electronic principle prototype and executed software, which mainly simulates the real environment of the integrated electronic system;The reconfiguration management monitoring system is the monitoring of the operation process of the integrated electronic principle prototype, the management of faults and the analysis of the reconfiguration. Real-time data exchange between the two systems through Ethernet.The system architecture diagram is shown in the Fig. 1.

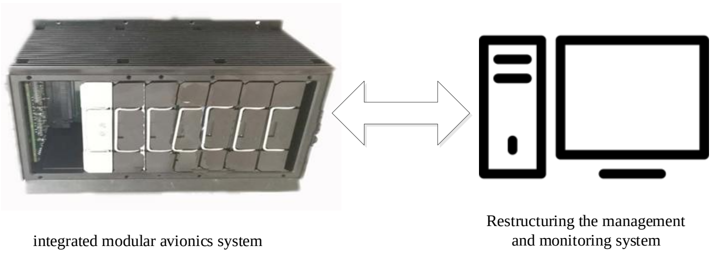

Fig. 1 The system architecture diagram

This paper uses the integrated modular avionics system reconstruction verification platform to verify the reconfiguration time analysis of the integrated modular avionics system.

The integrated modular avionics is deployed on the integrated electronic principle prototype. The processor of the integrated electronic principle prototype is PowerPC (P2020), and the corresponding operating system is the VxWorks embedded operating system.The reconfiguration management and monitoring system is deployed on an industrial computer, the processor of the industrial computer is Intel i5-6200, and the operating system is Windows 10.

In order to analyze and verify the reconstruction time, we inject different types of faults into the integrated modular avionics system for theoretical analysis and experimental verification. Specific failures include three types of failures, which are processor single-core failure, processor failure, and multi-level failure. Single-core processor failures include a failure of either processor A or processor B. And Processor failures include processor A failure and processor B failure. In the experiment of injecting three kinds of different faults into the integrated electronic system, the time consumption of the reconstruction and restoration process of the three kinds of faults by the reconstruction verification platform is shown in Fig.2.

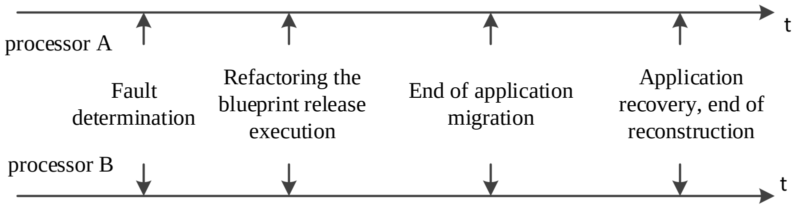

Fig.2 Time node of the reconstruction process

Table.1 shows the experimental data of three types of failures: processor overload, processor failure, and application component failure.

Table.1 Summary of experimental data

Type of the fault	Core 1 failure of processor A	Core 2 failure of processor A	failure of processor A
Theoretical value of reconstruction time	0.0004	0.0781	0.1415
The mean of the experiment	0.00039	0.0776	0.1406
Maximum difference	0.00015	0.0055	0.0106
Minimum difference	0	0.0004	0.0001
Mean difference	0.00001	0.0011	0.0009
Variance of experimental values	0.87998e-05	0.96100e-05	1.2250e-05

It can be seen from the experimental data that the experimental value variance data corresponding to the three types of failures is very small, which indicates that:

1. the reconstruction time produced by the reconstruction experiment is relatively stable;
2. the reconstruction experiment environment has little influence on the reconstruction process.
3. The execution effect of the reconstruction blueprint during the reconstruction process is better.

IV. CONCLUSION

This article is mainly based on the reconfigurable integrated electronic system architecture, to study the reconstruction time method of the integrated electronic system. First, the integrated electronic system model is explained. Then the reconstruction of the integrated modular avionics system is described. Analyze the types of failures that may occur during the operation of the system, and model the reconfiguration and migration process of the integrated electronic system.Use the comprehensive electronic system reconstruction verification platform to perform fault simulation to calculate and analyze the comprehensive electronic system reconstruction time under different faults. Use the comprehensive electronic system reconstruction verification platform to perform fault simulation to calculate and analyze the comprehensive electronic system reconstruction time under different faults. The experimental results show that it is different that the reconstruction time of the system reconstruction caused by different failure types. By optimizing the reconstruction blueprint and the reconstruction migration process, the time generated by the reconstruction process can be shortened.

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