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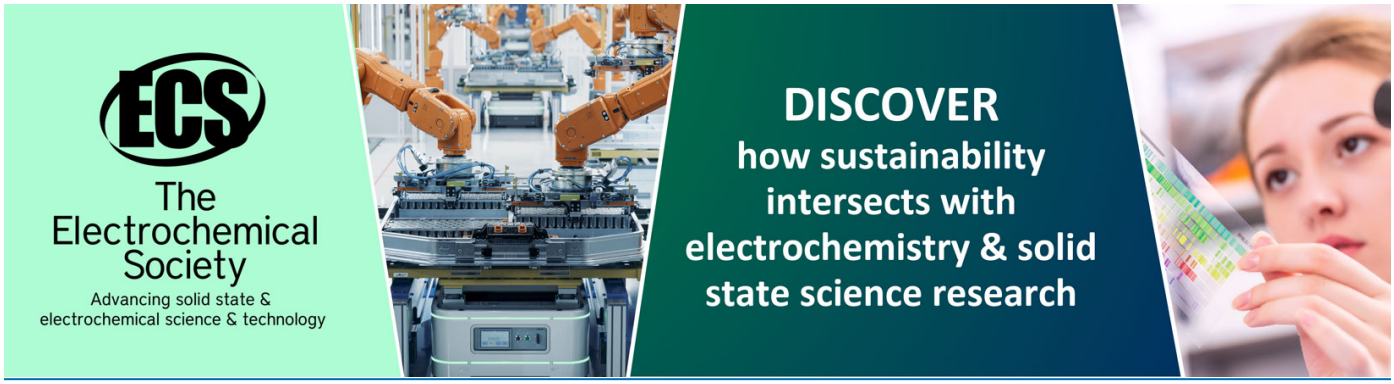

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Design and Implementation of Virtual Monitoring System for Distributed Heterogeneous Signal Processing Platform

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Abstract. There are many kinds of resources, complex structure and different standards in distributed heterogeneous signal processing platform system, so it is difficult to achieve unified management. Based on this, this paper designs and implements a high availability virtual monitoring system with resource networking and modelling. The system uses the hierarchical multi domain form to model the system network, and uses all levels of managers to manage them step by step, so as to realize the dynamic supervision of the whole system. The test results show that the proposed virtual supervision system can effectively and dynamically monitor the resources in the management system in real time, enhance the reliability and maintainability of the platform, and improve the resource management efficiency of the distributed heterogeneous signal processing platform.

1. Introduction

A variety of heterogeneous signal processing platforms can be integrated into distributed heterogeneous signal processing platform, dispatch and deploy special signal processing resources for complex tasks in different scenarios, give full play to the processing advantages of the corresponding resources in the platform system, and cooperate to complete signal processing tasks. It has gradually become the development trend of general computing architecture [1-2].

Distributed heterogeneous signal processing platform provides powerful functions and convenience for complex signal processing tasks, but it presents greater challenges in resource monitoring and management. On the one hand, due to the existence of a large number of heterogeneous signal processing resources with complex structure in the system, once a fault occurs, the investigation will be time-consuming and laborious, and the reliability and maintainability of the signal processing platform will be seriously reduced; on the other hand, there are different communication standards between heterogeneous resources in the system, and incompatible interfaces and drivers. So it is difficult to carry out unified monitoring and management of resources in the system. [3-5].

Based on the theory of predecessors, and combined with the characteristics of distributed heterogeneous signal processing platform, a high availability virtual monitoring system with resource networking and modeling is designed and implemented in this paper. Software and hardware resources modular design ideas of SCA are used for reference by the system[6]. Firstly, the resources in the system are modeled and networked in the form of hierarchical multi-domain. Then, the platform system is described and analyzed by a unified standard description specification. Finally, the system resources at each level are managed by hierarchical managers. The real-time information of the resources in the system is acquired by the managers at all levels, and the information is reported step by step to realize the dynamic supervision of the whole system.

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2. Distributed heterogeneous signal processing platform system architecture

In order to shield the differences between heterogeneous signal processing resources, enhance the flexibility of cooperation between hardware and software resources, and improve the efficiency of unified management of system resources, the hierarchical architecture of heterogeneous signal processing platform defined by software is used for reference in this paper [7-8], and hierarchical modelling is adopted to model the platform system. As shown in Figure 1, the platform architecture is divided into hardware platform layer, driver abstraction layer, intermediate network layer, management service layer and application layer.

Hardware Platform Layer: As the specific executor of signal processing tasks, hardware platform layer is mainly composed of several heterogeneous signal processing platforms, such as ATCA (Advanced Telecom Computing Architecture), VPX, CPCI and other computing platforms. Different platforms contain different performance processing units, including FPGA, DSP, PPC and so on. Using the interconnection of different processing units within the platform and the collaborative processing between different platforms, heterogeneous platforms can efficiently meet the complex tasks of different scenes.

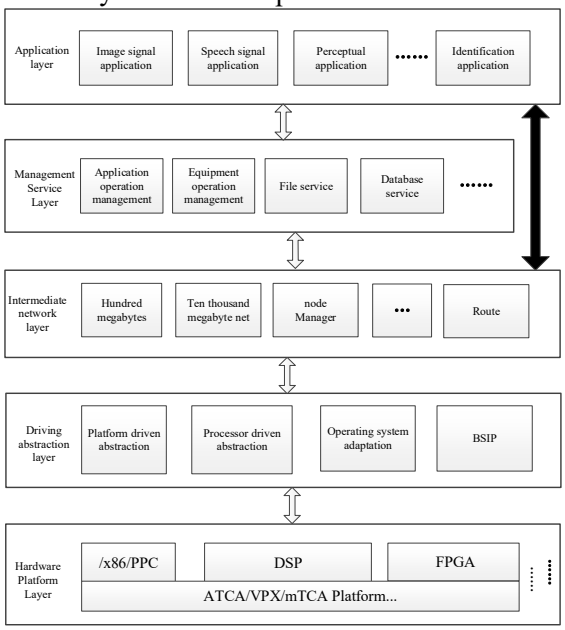

Fig. 1. Heterogeneous signal processing platform architecture

Driving abstraction layer: In order to shield the differences between heterogeneous resources, standardized the modelling and encapsulation of each type of signal processing platform, the unified standard interface is constructed by driver abstraction layer, so that the underlying heterogeneous resources can cooperate to complete signal processing tasks.

Intermediate network layer: it is mainly for different resources of communication standards to provide network channels, node management and routing. Through the middle network layer, when the system performs signal processing tasks, the managers at all levels communicate with the superiors and the resources, and process the data transmission to provide the optimal route and implementation scheme for signal processing services.

Management Service Layer: The task of management service layer is to invoke the managers of different service types according to the upper application, refine the scheduling and deployment information of resources, improve the overall signal processing efficiency of the system; at the same time, coordinate the processing of multithreaded tasks within the system reasonably, and enhance the stability and availability of the system.

Application layer: it is mainly the specific applications developed by users according to needs. Due to the virtualization of the underlying hardware and the encapsulation of the driver abstraction layer, developers can develop their own applications according to the actual signal processing tasks without

considering the differences of the underlying heterogeneous hardware, which improves the portability and reusability of the application.

3. Design of monitoring system based on hardware and software resources virtual networking

The virtual supervision system designed in this paper adopts hierarchical multi-domain networking, modelling and hierarchical management mode to supervise the resources in the system. The model is shown in Figure 2. The supervisory system mainly carried on the network modelling from the processor level, the board card level, the platform level, the domain level and the system domain level as well as the client side. At the same time, the supervisory system uses the hierarchical management, the step-by-step report pattern, through the processor and the board card, the board card and the platform, the platform and the domain, the domain and the system domain, the domain and the client level by level reports, finally, the real-time situation of the whole system is understood through the client.

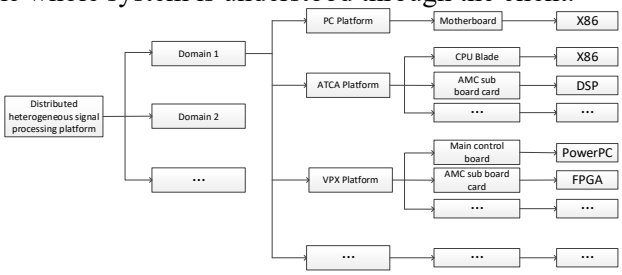

Fig. 2. Hierarchical multi domain model for distributed heterogeneous signal processing platform

3.1. System resource virtualization and networking modelling

In order to monitor and manage the hardware and software resources in the system, it is necessary to shield the differences between heterogeneous resources and unify the system resource specification standards, so that managers at all levels can obtain the information of hardware and software resources clearly. In this paper, the idea of level-by-level abstraction is applied to network modelling of the system [9-10], that is to say, each level of heterogeneous resources is virtualized by constructing a unified description specification and interface specification, and then the abstract virtualized resources at all levels are networked modelled according to the logical topology structure, and finally the distributed heterogeneous signal processing platform system with network hierarchical multi-domain is formed.

In the process of hardware virtualization, according to the attributes and functions of hardware resources, the hardware resources with similar attributes or functions are abstracted into the same kind of virtual hardware, and the hardware resources with different attributes or functions are abstracted into a kind of virtual hardware[11-12]. Then according to the attributes and functions of hardware resources and the connection between different hardware, virtual hardware resources are abstracted into a unified network architecture model in accordance with the topology of board, plug, socket processing node, communication node and switching node. As shown in Figure 3, in the ATCA platform topology abstract model diagram, where a FPGA and a DSP processor chip are mounted on a board in the ATCA platform.

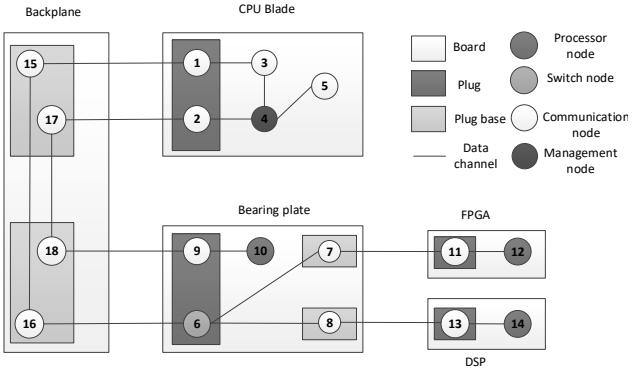

Fig. 3. Topology abstract model diagram of ATCA platform

In the process of software virtualization implementation, as shown in Figure 4, the components are modeled according to their parameters, attributes and functions, and then according to the function and connection between components and the running environment, the corresponding constraint information is added to build the software package. Finally, when the signal processing task is executed, the corresponding components are selected from the software package and assembled into the required applications to complete the signal processing task. At the same time, the component model, the software package model and the application model are stored in the platform database as resource reserve and called when needed.

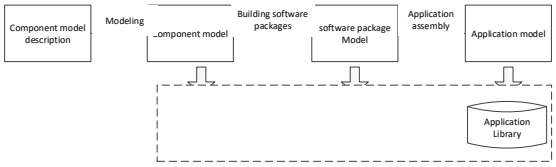

Fig. 4. The abstraction principle of virtual software resources

3.2. Hierarchical description and analysis of system resources

Based on SCA software configurable idea [13], heterogeneous signal processing platform system can dynamically generate resource information description files according to the needs of signal processing tasks. The description file includes resource scheduling and deployment information, running environment, connection relationship and other constraints. In the process of signal processing, the platform system parses the description file through the parser, completes the deployment of resources and the configuration of the running environment.

Description file generation process as shown in Figure 5, using a unified system description format, hierarchical networking on the system hardware, as well as the application carried on the hardware resources are described. Description files mainly describe the properties, functions, topology, connection relationship, running environment of resources, and finally generate description files.

When the signal processing task is executed, the system description file is automatically loaded. By parsing the system description file with the parser, we can get the topology structure, running environment, connection relationship of the required resources and the application information carried on the processing nodes at all levels. According to these information, corresponding resources scheduled and deployed by platform system to complete corresponding signal processing tasks.

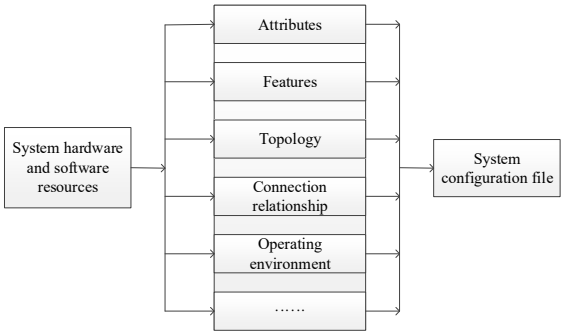

Fig. 5. The process of system description file generation

3.3. Hierarchical management of system resources

Distributed heterogeneous signal processing platform system uses hierarchical management mode to manage the system, according to the system domain, domain, platform, board, processor and client, constitute a hierarchical management system. Each level node has a manager, and which is responsible for managing the corresponding level resources. In system supervision, each level manager is responsible for collecting resource information of the corresponding level, and then report the level profile information to the upper level manager at a certain frequency.

As illustrated in Figure 6, when the system is running, the processors report to the processor manager at a certain frequency running state, throughput, latency, occupancy rate, etc., to provide reliable information for maintaining the stability of the platform system. At the same time, the processor manager will collect the application information on each processor in real-time during the execution of signal processing tasks, and provide data support for the upper application to schedule deployment resources while processing other tasks. Similarly, through the processor and board card, board card and platform, platform and domain, domain and system domain managers at all levels report their summary information in turn, and finally display in the client interface, thus realizing the visual supervision of the system.

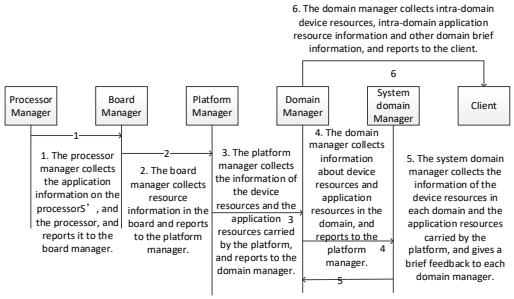

Fig. 6. Hierarchical management system

4. Test validation

As shown in Figure 7, in order to verify the virtual supervisory system proposed in this paper, a distributed heterogeneous signal processing platform environment composed of PC platform, ATCA platform and VPX platform is constructed. The board of PC platform carries X86 processor, ATCA platform carries a GPU processor, and the board of VPX platform carries an FPGA processor.

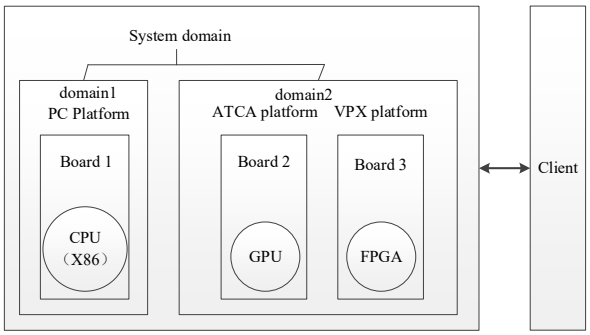

Fig. 7. Test environment

The validation process of the supervisory system is as follows: firstly, the descriptive files are generated according to the descriptions of the three platforms' resource attributes, connection relations and running environment. Then, the platform system is run, and the parser of the platform system parses the descriptive files, and the managers report the system resource information step by step. Finally, through the visual interface, the client chooses the content to be monitored. The system can monitor four aspects: local devices, local applications, remote devices, and remote applications. Figure 8 is local application supervision.

The test results show that the supervisory system designed in this paper can dynamically monitor resource status, resource occupancy rate, application processing delay, application load, application parameters and so on. It provides intuitive system data for complex system management and greatly improves the management efficiency of distributed heterogeneous signal processing platform.

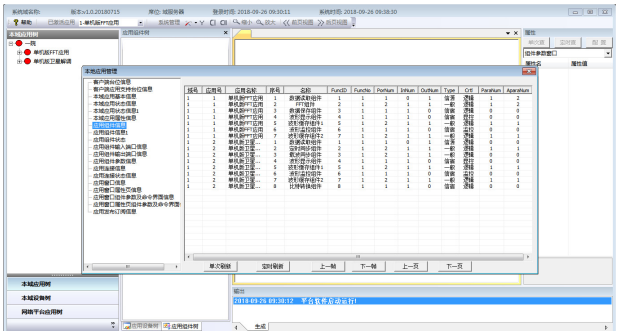

Fig. 8. Local application supervision

5. Conclusion

In this paper, the idea of hierarchical multi-domain and hierarchical management is used to model the resources in the system. The virtual supervisory system of distributed heterogeneous signal processing platform is designed and tested on the hierarchical heterogeneous signal processing platform defined by software. The test results show that the virtual supervisory system proposed in this paper improves the resource cognition of complex heterogeneous signal processing platform, enhances the reliability and maintainability of the platform, and greatly facilitates the unified management of virtualized resources of distributed heterogeneous signal processing platform.

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