Research on the Reliability of the High-performance Computer Interconnection Network

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Abstract—With the constant progress of science and technology, high-performance computer has experience a long development course since its birth, and the speed for the computer technology upgrade has also become one of the rapidest scientific technologies. The huge changes in the constant improvement of the computational speed, the increasing operating modules and hardware scale, and the development of the software technology have imposed serious challenges to the whole computer; meanwhile the constant increase of the operating modules has reduced the reliability of the interconnection network. Therefore, a research on the reliability of the high-performance computer interconnection network has been conducted in the research in order to improve the reliability of the interconnection network between the modules.

Keywords-High-performance computer; Interconnection network; Reliability research

I. INTRODUCTION

high-performance computer is the kind that can execute large-scale data process and high-speed computation that is impossible for general PC, having the characteristics of large capacity and fast computation speed. In the era of global informatization, high-performance computer has become the signal for a country's scientific research strength, and has been widely used in m military, medial equipment, experiment and engineering computation, etc. playing an irreplaceable role in protecting national security and pushing social progress and scientific growth. Therefore, it is imperative to make sure the operational reliability of the high-performance computer, to avoid the military and economic loss in the event of sudden fault.

II. RELIABILITY HISTORY OF THE CURRENT HIGH-PERFORMANCE COMPUTER

High-performance computer has experienced a long development course since its birth, during which the operational speed, software and hardware technology, computation and application have achieved a huge development and change.

The budding stage. High-performance computer was originated from the first giant-scale computer in the world. It was designed in 1962 at the operating rate of 1Mflo/s.

then it developed to the world's earliest vector machine STAR-100. However, due to its long research period, its technology can no longer meet then market demands after it was finished. But there is no deny that the computer at this stage was the basic development history of high-performance computer.

Rapid development period of high-performance computer. 1976~1990 was the rapid development period of high-performance computer. During the dozens of years, there invented vector machine, one of the major expression mode at this stage. Its development was mainly attributed to its benefits to improving computational speed. It can be mainly reflected in three points: vector machine is helpful to fully use the stream line to shorten the period and improve the main frequency; it is helpful to fully use multiple-function components; and it can reduce the number of the auxiliary orders in the procedure and shorten the procedure period time.

The mature period of high-performance computer, since 1990s, high-performance computer has already got rid of the stagnant situation and started the fast-developing period. During this period, new technologies has never ceased its flow and the computational speed also grew to from the earlier Mflo/s.

III. THE CURRENT RELIABLE TECHNOLOGY USED FOR HIGH-PERFORMANCE COMPUTER

In recent years, the application field of the high-performance has been further expanded, and so has the requirement for its performance. Especially in the field of aerospace and some special fields like national security field, there has been special requirement on its reliability, since in case of any fault, there will be serious consequence. But in the actual application, it is an objective event for computer system fault, and there is no absolute faultless system. Therefore, some reliable technology is needed to make sure the system can continue with normal or basic work after the fault happens, and self-renovation or restoration while avoiding serious loss. However, the reliability technology used in high-performance computer technology can mainly be divided into this:

Technique of fault avoidance. The technique-avoidance technology of the high-performance computer aims to aid the scientific management through

accurate design at the earlier stage of design to avoid as many as mistakes possible in computer and try to reduce the possibility of computer system components invalidity. Through practice and the statement of various literature, the invalidity of the components has something to do with the quality of these, meanwhile, the using environment, operating temperature, circuit scale and the complexity of the assembly all have some impact on the components. Therefore, while choosing computer components, the components shall have a high reliability, which is the most important foundation for the validity of the components. Then, a series of preparation shall be made for the heat design and environment-proof design at earlier stage. Only in this way, can it be possible to improve the reliability of the component, and further improve the reliability of the computer system.

Static technology is also known as a fault shield technology which can guarantee the fault corrected or isolated before it comes to the output module by use of information or hardware redundancy, based on the fault on high-performance computer, in order to eliminate the impact of the fault to the computer. Static redundancy exists on the precondition that the computer system itself admits of the fault. Generally speaking, static redundancy technology can adopt the measures of component redundancy, data access redundancy and information redundancy. Component redundancy is mainly used for fan, power, clock source and other single-point fault or switch-off part of the high-performance computer. Especially the power may lead to over-high temperature or unsteadiness for the surplus process data, and result in power fault, in the process of the operation of the high-performance computer. Therefore, power redundancy shall be under more deliberate protection in the process of design. Data access redundancy can also be construed as a kind of component redundancy, which can provide corresponding spare path for the system magnetic array. A common redundancy technology in the scope of information redundancy is correction code which generally achieves fault inspection and coverage by adding some redundant information into the actual data. According to the experiment results of the various computer design manufacturer, the frequency of the fault happening to the computer without using correction code protection is times or even hundreds of times more than those using correction code.

Dynamic redundancy. Dynamic redundancy uses standard module configuration to make sure, once any fault happens to the computer system while in operation, it can automatically detect the fault and accurately diagnose the location of the fault, and then recover the operation through restructuring the data or adopting recovery measures. Dynamic redundant technology generally has three links: fault detection and diagnosis, restructuring and recovery technology. (1) High-performance computer fault test and diagnosis mainly to accurately locate the fault, regardless of whether the computer is connected to the network or not. But meanwhile, if the computer can connect to the network, the fault can be more accurately located. Fault test technology shall also have the related technology like monitoring timer and correction code. Correction code also includes different encoding technology like recycle redundancy verification code and parity check code. While detecting the location, the correction code and verification code can be used to check in which link the fault happen; (2) restructuring technology, as a dynamic redundancy, is an important technical measure to eliminate computer fault, and its major function is, when the computer detects out the fault cause and location, the system can automatically use the related back-up to replace the fault organization; without the replaceable appliances, the restructuring technology will separate the fault position and reduce the grade of the system to keep normal application of the computer.(3) restoration technology is the most important link for the unrecoverable fault after the fault happens, such as retrial is one of the important methods in restoration technology.

Online replacement. When fault happens to the high-performance computer system component, the component can be replaced online to get the system recovered to the original configuration mode. Online replacement mode component redundancy can greatly improve the system reliability. However, due to the plentiful and complicated computer appliances, not all the modules are suitable for online replacement, therefore, preparation is needed before replacement and then it is required to conform whether the fault component is suitable for online replacement. Generally, the components suitable for online replacement include: disk, fan and unit panel, etc.

IV. THE RESEARCH RESULTS ON THE RELIABILITY TECHNOLOGY OF THE CURRENT HIGH-PERFORMANCE COMPUTER.

Fault tolerance analysis on high-performance computer interconnection network. Currently, the issue of the reliability of the interconnection network can be measured with multiple indicators with tolerance as the widest applied. The superiority of the tolerance performance is closely linked to the tolerance degree. The higher tolerance can produce a better tolerance performance and the higher corresponding reliability. Tolerance means tolerating fault, not the mistake by literal mean. When there is something with the equipment, another one can come to make up and make sure the normal operation of the system. Computer system fault tolerance refers to the ability to detect the faults from the operation of the software and hardware in the software application procedure, and the ability to recover from the faults. It is generally measured from the aspects of reliability, feasibility and measurability, etc.

High-performance computer interconnection network fault diagnosis analysis

There are mainly three methods for interconnection network diagnosis [3]: (1) analogue diagnosis, which can be divided into two types: PMC model that classifies the network system into plentiful node computer in network fault diagnosis and then make mutual test between the node points, and after the test, compare the test results to detect the fault status; the second is the comparison model which needs to use some related fault diagnosis calculation, while using the model for interconnection network fault detection, to finally realize the existence of the fault detection; (2) OMMH fault diagnosis. OMMH is optical interconnection network multiple grid hypercube,

which has all the advantages of grinding network and hypercube, therefore, while using OMMH fault diagnosis, it has effective characters and higher fault diagnosis accuracy, and OMMH fault diagnosis has greatly improved the overall efficiency of the interconnection network fault diagnosis, serving as a high-end diagnosis means currently in our country; (3) folding cubic interconnection network tragic fault diagnosis. Fault diagnosis also needs the support of tolerance technical to better make sure the correctness of diagnosis result. In the folding cubic interconnection network, use pessimistic fault diagnosis can effectively improve the validity of the fault.

V. THE DEVELOPMENT TREND OF THE CURRENT RELIABILITY TECHNOLOGY OF THE HIGH-PERFORMANCE COMPUTER

The reliability design of the multi-core processor. With the constant development of computer, the integration of the computer processor is growing, more frequently leading to processor fault. The fault can be divided into hard and soft faults. Hard fault is caused by computer processor silicon and other metal sheet; while the soft fault is from the external element, such as the instant fault by external particle radiation. However, high-performance computer at present generally use multi-core processor, which has lower CPU occupation rate, quick operation speed and strong multi-tasks tackle capability, and thus is reliable and not easy to be stagnant while the application procedure is in operation. Multi-core processor is not just an accident. Using sharing components between the cores, the software fault of one core may spread to another. Therefore, the application of multi-core processor is the opportunity for reliability design and also the challenge. Only by constantly improving the research level, can constant benefit the high-performance computer.

The strong multi-direction memory protection technology. It can be discovered from the fault maintenance of the whole computer, memory fault holds a higher proportion in high-performance computer system fault. Therefore, the strong memory fault protection has become an important protective technology. Various memory fault tolerance technique can be comprehensively referred to improve the reliability of the memory, specific for soft and hard fault of the memory, for example, achieve the reliability of the electricity and machine by reinforcing the storage. Furthermore, in the process of designing some high-performance computer, it can also use memory cleaning, memory spare parts and memory mirror image to finish the reliability design technology of the processor.

The development of blade-type structure. With the increasing number of the servers, they are also seeing a gradually changing development direction and increasingly smaller size. The server with lower energy consumption and higher expansion has become the primary demand structure of high-performance computer.

The server of blade structure comes to being as a high-density server and is different from the traditional equipment cabinet server. It has multiple card-type server unit plate in the shelf equipment cabinet on the standard height to make it more reliable with higher density. Due to the characteristics of the blade server, the blade in the structure is independent and can separately finish the different functions of storage module, application module and network module. In the blade structure, the modularized redundancy structure is commonly used to realize hot plug of the key parts like power, network and fan, as a result, it can eliminate the single-point barrier. At the same time, the hot plug can make the blade replaced any time, so that the users can choose the corresponding blade based on its own specific demands, and then insert it into the structure. The structure can make sure system replacement with a short time to reduce the time for maintenance, make sure user system persistent operation, improve the available performance. It is an important direction for the future development of computer server.

VI. CONCLUSION

High-performance computer has been widely used in cosmology, meteorology and other computation-intensive fields for its strong and fast computational speed. Current, we have achieved excellent achievement in high-performance computer research and grasped some key technologies. While the high-performance computer technology is advancing, it is also coming to applications in all the fields in our country. But there is no denying there remain some problems in specific application in some fields. However, in this rapid-developing society, only by bravely facing the challenges, can we win more development chances. What comes with the improvement of the high-performance computer functions are the increasing modules and the scale of interconnection network. To make sure the reliability of the high-performance computer system, it must rely on scientific design and fault diagnosis to make sure the reliability in interconnection network.

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