Information Fusion-oriented Design and Application of Multiprocessor Computer Software and Hardware

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Abstract

Most systematic structure models of information fusion technology only describe the data processing of information fusion only from the concept, without combining with practical engineering, which cannot effectively the fusion problem in the engineering. Based on the basic idea of information fusion, the information fusion-oriented design method of multiprocessor computer software and hardware is first proposed in this article, combining with the software and hardware design in the practical engineering. The system structure based on the information fusion technology is first established, and the key technology and methods to solve the software and hardware design for information fusion are put forward based on that, and finally, the application of the comprehensive data processing computer proves the effectiveness and feasibility of the system structure and the software design method in the article. The use of the system structure and the software hardware design method proposed in this article can fuse the seemly messy information analysis in the computer system, with stronger data processing capacity, higher reliability, better expansibility and environment adaptability, and create a new way for the research combining the system structure based on the information fusion technology and the practical engineering.

Keywords: Information fusion, Multiprocessor computer, Design of software and hardware

1. Introduction

At present, the technology of information fusion has been applied in many domains, and the relative researches main centralized in the fusion algorithms, the fusion structure, the modeling, and the implementation. Since 1980s, many experts in different domains have proposed various information fusion architectures according to the characteristics of their own domains, combining with the information fusion technology (Zhu, 2006, P. 114-115). However, most of these structural models only described the concept of the data processing of information fusion, without the combination with the actual engineering, which could not effectively solve the fusion problem in the engineering (Hua, 2008 & Wang, 2008 & He, 2008 & Wu, 2008). The basic idea of this article is to utilize the basic principle of information fusion, combine with the software and hardware design in the practical engineering, and construct the high-reliability architecture based on the information fusion technology, and research relative key technologies suiting for the software and hardware technology.

Based on the theory of information fusion, the architecture based on the information fusion technology is first established, and then the key technologies and methods about software and hardware design with high reliability are proposed and realized, and finally, the application of the integrated data processing computer proves the effectiveness and feasibility of the architecture and the software and hardware design methods in the article.

2. High-reliability computer system structure based on the information fusion technology

The architecture of information fusion can be divided by many methods, and according to the processing mode of information fusion, the information fusion architecture can be divided into three kinds, i.e. the centralized architecture, the distributed architecture, and the mixed architecture (Tan, 2008).

The centralized architecture means that the information acquired by various sensors is directly transferred to the information fusion center without any processing, and accomplish the final fusion processing after combining and reasoning. This architecture is appropriate for the multi-sensor information fusion on the isomorphic platform, and its advantage is that the information processing loses little, and its disadvantage is that the bandwidth of the communication network should be wider.

The distributed architecture is to transfer the compressed sensor data to the fusion center after accomplishing certain quantity of computation and task processing at various sensors, and implement combining and reasoning for multi-dimensional information received at the fusion center, and finally accomplish the fusion. This architecture is fit for the multi-sensor system allocated at remote place, with certain information loss and communication bandwidth.

The mixed architecture has both the characteristics of the centralized architecture and the distributed architecture, and in this architecture, there is processed sensor data which is transferred to the fusion center, and there is unprocessed sensor data which is transferred to the fusion center. The mixed architecture can flexibly design the multi-sensor information fusion processing system according to different situations. But the stability of this architecture is bad.

According to the basic idea of the information fusion, this system mainly concludes the data and information acquirement module, the data and information preprocessing module, the data and information fusion module, and the information output module. The system is composed by five processors, including the node 1, the node 2, the node 3, the node 4, and the master node. The node 1, the node 2, the node 3, and the node 4 respectively acquire data or information and pre-process the data and information under the distribution of the master node, and transfer the result to the master node, and the master node will fuse and output the information (seen in Figure 1).

2.1 Module of data and information acquirement

The module of data and information acquirement is a data detecting system based on network. The node 1, the node 2, the node 3, and the node 4 are detected by the master node on the network, and then feed the result back to the master node. At the same time, the module will judge whether the data flow or the information flow pass, and capture and analyze the data flow and the information flow, and transfer the analysis result to the module of the data and information preprocessing.

2.2 Module of data and information preprocessing

The module of data and information preprocessing is a principle part of the system. In this module, various nodes will independently work according to the indication of the master node. To enhance the reliability of the system, the design method of high-reliability will be adopted in this module.

2.3 Module of data and information fusion

The module of data and information fusion is the core part of the system, and variously different relationships will exist in the data and information acquired by the module, so the principle task of this module is to implement different types of fusion analysis of information according to different relationships. Generally speaking, the main relationships among data flows and information flows include repetition, concurrency, and association. For the repetition and concurrency, the information flows and data flows can be filtered and recombined a piece of new information. For the association, the attribute of the next data or information should be provided as the institutive and deep information for the next output module.

2.4 Module of data and information output

The module of data and information output is to output the data to the final user and accomplish the function of the whole system according to the result of the fusion and analysis module.

3. Key technologies of the software and hardware design of the high-reliability system structure

Except for the architecture based on the information fusion, to achieve the requirement of high-reliability design, the key technology about the software and hardware design need to be studied too.

3.1 Collaborative management technology

Figure 2 shows the collaborative management software design, the important part of the software design of this system. When the system is power on, the master node distributes the tasks to all nodes in the system, and then the master node starts the detecting task and detects the works of various nodes, and maintains the backup databases of various nodes at the same time. If one node makes mistakes, the master node will distribute the error task to next node.

3.2 Design technology of the distributed name database

The function of the distributed name database is to share the data in the application programs, and periodically refresh the data by the form of broadcast. Each node in the system has a backup in the name database. Any modification will be copied as a backup and transferred to the system, and one shared value will be added to the name database. The distributed name database allows the association between any values with the name, for example, the ID of distributed message queue has a unique name. The distributed database provides a conversion of name-to-value-and-type, and it permits the entrance database can be interviewed by the name, the value, and the type.

3.3 Design technology of the distributed message queue

The distributed message queue can run on local or remote task, and share any communication mediums. Figure 3 describes the diffusion process of one message in the system. The normal running of the system must be based on the diffusion of messages.

3.4 Synchronous design technology among nodes

One mode to realize the time synchronization in the distributed system is to use the time server processes to provide the time corresponding with the clock itself. This time server is equipped by proper receiver to synchronize UTC (Universal Time Coordinated, a kind of international standard time based on the atom time), and periodically refresh the time. After comparing the time of various nodes with the time of the time server, various nodes refresh their times and keep the time synchronization. This method can eliminate the timer interval change induced by the clock drifting among various nodes, and ensure the communication instantaneity of various nodes.

3.5 Task allocation and remote call technology

The task allocation and remote calls of various nodes in the system are accomplished by the master node. Generally, the static allocation and the remote call are adopted.

(1) Static allocation

The system software is divided into different tasks artificially, such as task1, task2, taks3, task4 …. These tasks will stay on all nodes, waiting for being awaked. All tasks are artificially allocated on corresponding tasks.

(2) Remote call

When the system is power on, the master node checks the heartbeat of the system nodes (if the system is normal, the heartbeat will occur), to confirm whether the node starts normally, and then awake the tasks of various nodes which needs to be executed by the network.

3.6 Network switch technology

The network switch technology is divided into the second-layer switch and the third-layer switch. The second-layer switch occurs in the data link layer, and it realizes the switch by adjudging the address of MAC. The exchange of traditional meaning is the concept on the second layer, i.e. transmitting the transfer frame on the data link layer. The transmission on this layer doesn't evolve the equipment and addressing among networks. The third-layer exchange is constructed on the IP layer, and it transmits the data only depending on the data link layer. The equipment with the third-layer switch function is a second-layer switchboard with the third-layer routing function, but it is the organic combination, and it doesn't overlay the hardware and software of the router on the switcher in LAN. The third-layer switch routing protocol includes RIP, OSPF, and BGP.

4. Applications in the integrated data processing

Combining with the key technologies of above architectures and the software and hardware design, this system has many advantages such as large covering area, high detection performance, and high reliability when it is applied in the integrated data processing. Figure 4 shows the software structure of the integrated data processing computer.

4.1 Design of the work mode of the integrated data processing computer

The software of the integrated data multi-processing computer adopts the available design with high performance of failure recovery.

(1) When the system is power on, the master node and other nodes connect with the switch board S1, and switch off the switch board S2 (seen in Figure 5). The connection between the nodes and the switch board is controlled by the redundancy software of the double-network card on their own boards, and if the link failures, the linkage will be switched to S2, and the system will work continually.

(2) The work process of the system can be described as follows. First, the master node will detect the states of various nodes, and start the node heartbeat healthy detecting program, and if the detection is normal, it will report that the system is normal, and then distribute tasks to four nodes. Node1 and nodee3 have same task, and node2 and node4 have same task. Next, the master node controls the node3 and the node4 not to

transmit data for the network, but the node3 and the node4 can receive the data normally. And the master node enters into the detection state of the system. The difference between the nodes 3, 4 and the nodes 1, 2 is that the nodes 3, 4 can only receive the data on the network, but cannot transmit the data to the network.

(3) The work of system redundancy is designed as follows. When the master node detects various nodes in the system, the double-network card redundancy software is also in the work state (seen in Figure 5). If the communication between the node and the switch board S1 failures, the double-network card redundancy software will switch the network link to S2, and the system continues to work (seen in Figure 6). If the switch failures, or the link with S2 failures, the master node will detect the node error in 3 seconds, and awake the backup nodes and transfer the data to the network, and the backup node will replace the error node to work (seen in Figure 7). The redundancy ends.

4.2 High-reliability design core of the integrated data processing computer

Figure 8 is the architecture chart of the high-reliability design of the system. Multi-computer collaborative management is the core of the high-reliability design to realize the management function of the multi-computer system, including the task distribution, the power detection of node, the heartbeat healthy detection of node, and the node redundancy management (if the node 1/2 failures, the node 3/4 will replace it to work).

4.3 Performance analysis

In virtue of the architecture and the high-reliability software design methods proposed in this article, the integrated data multi-processing computer has following advantages.

(1) Serial link and point to point link. This system needs not the cable link, and it can directly realize the Ethernet switch on the standard board, and makes the CPCI realize the topology structure of series, point to point link, and switch.

(2) Good expandability. The system can overcome the disadvantage that the CPCI bus expansion needs the active bridging, and the expansion ability of the sharing and parallel bus. At the same time, it can link with the multiple cases to realize the concept of the big virtual board.

(3) High availability. In the system, each node card links with two switch cards, and one switch card is the backup, and the node card is also designed with a backup. Whether the node card or the switch card failures, the backup card will be switched automatically, and the system needs not to be halted.

(4) High bandwidth. The bandwidth of each slot in the system can achieve 2Gb/s, and the theoretical bandwidth of the case can achieve 48Gb/s. The Ethernet network with the bandwidth from 10Mb/s to 1Gb/s can be selected to enhance the flexibility of the system and the system.

(5) Strong operation ability. Because the Ethernet interconnection technology is adopted, and each node slot is equipped by the processor board, the operation capability of the whole system will be largely enhanced. When the intensive computation requirements are satisfied, the cost of the system will be reduced largely.

5. Conclusions

With the development of the computer technology and the further progress of the system integration technology, some high-end users need higher requirements for the processing capacity of computer. The processing capacity of single computer (processor) cannot satisfy high-end users' demand, and multiple computers (processors) need work collaboratively to accomplish the task of data processing.

The use of the system structure and the software hardware design method proposed in this article can fuse the seemly messy information analysis in the computer system, with stronger data processing capacity, higher reliability, better expansibility and environment adaptability, and create a new way for the research combining the system structure based on the information fusion technology and the practical engineering.

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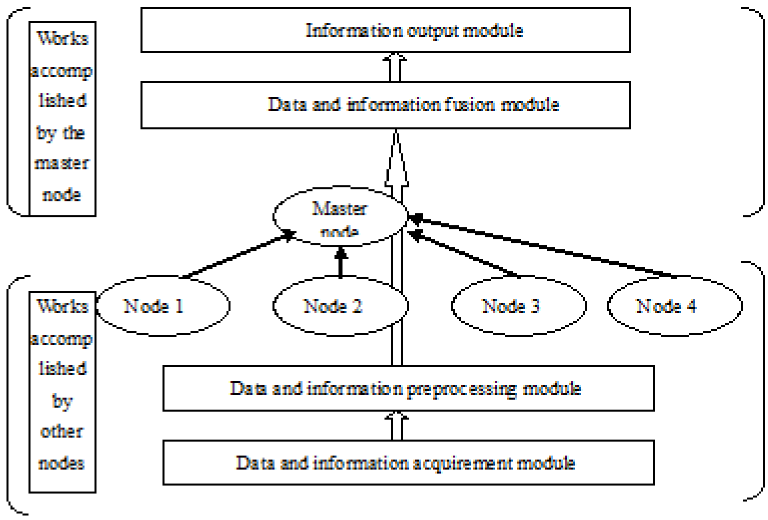

Figure 1. Architecture of the High-reliability Computer

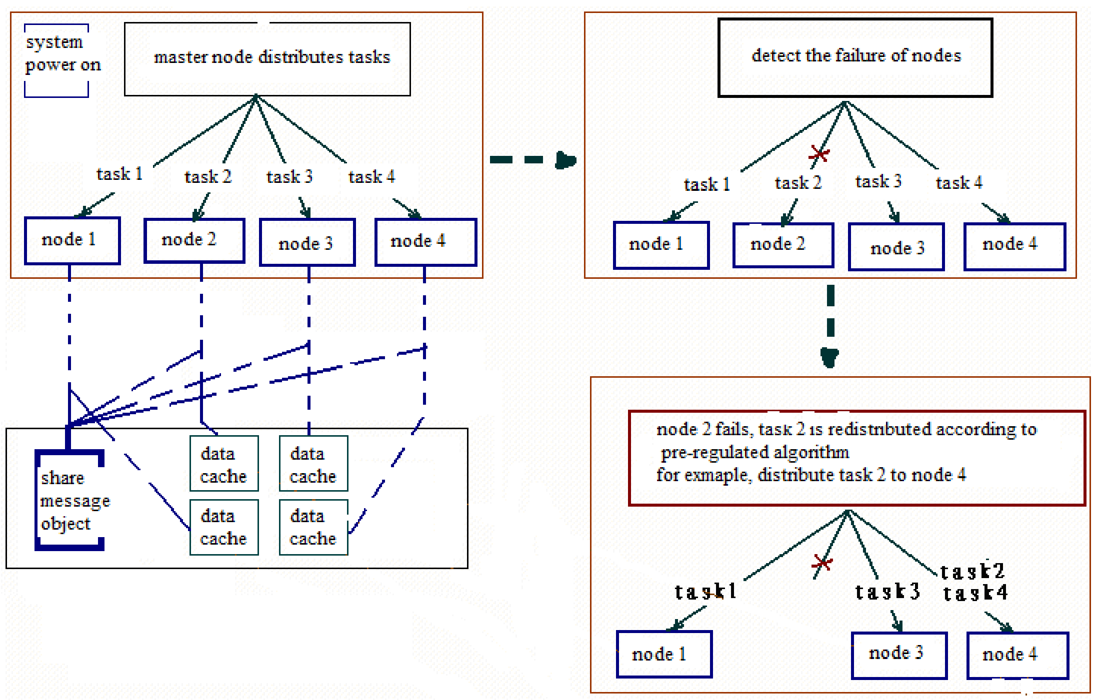

Figure 2. Structure of the Collaborative Management Software

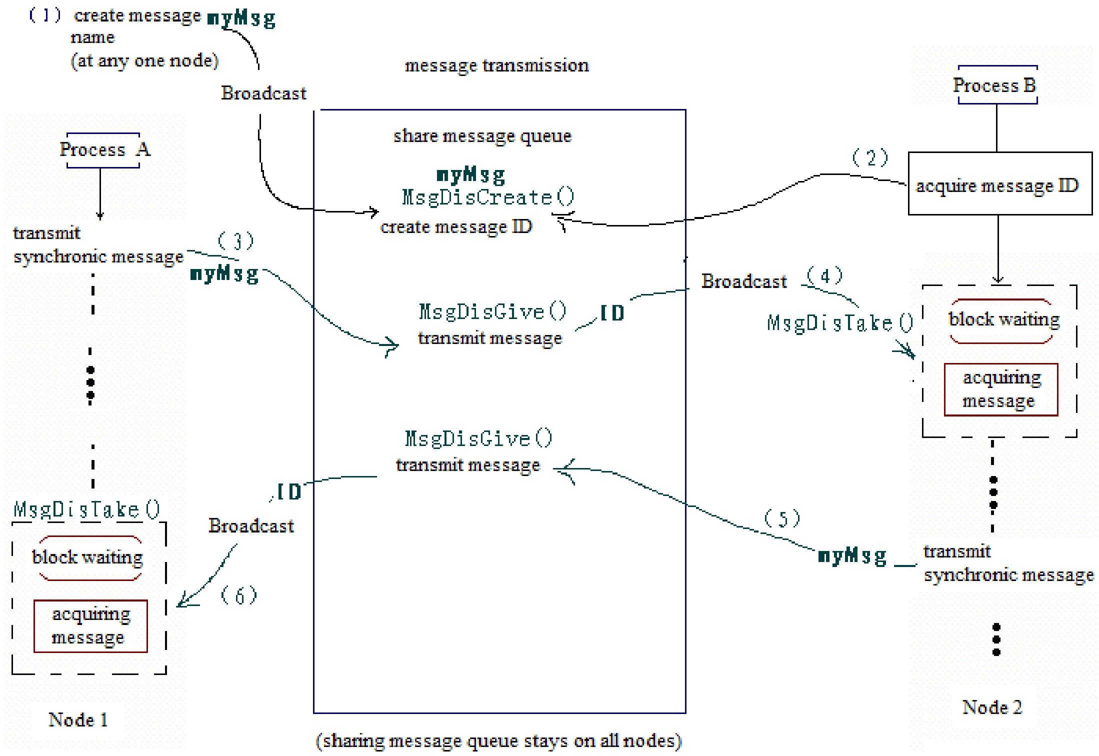

Figure 3. Diffusion Process of Message in the System

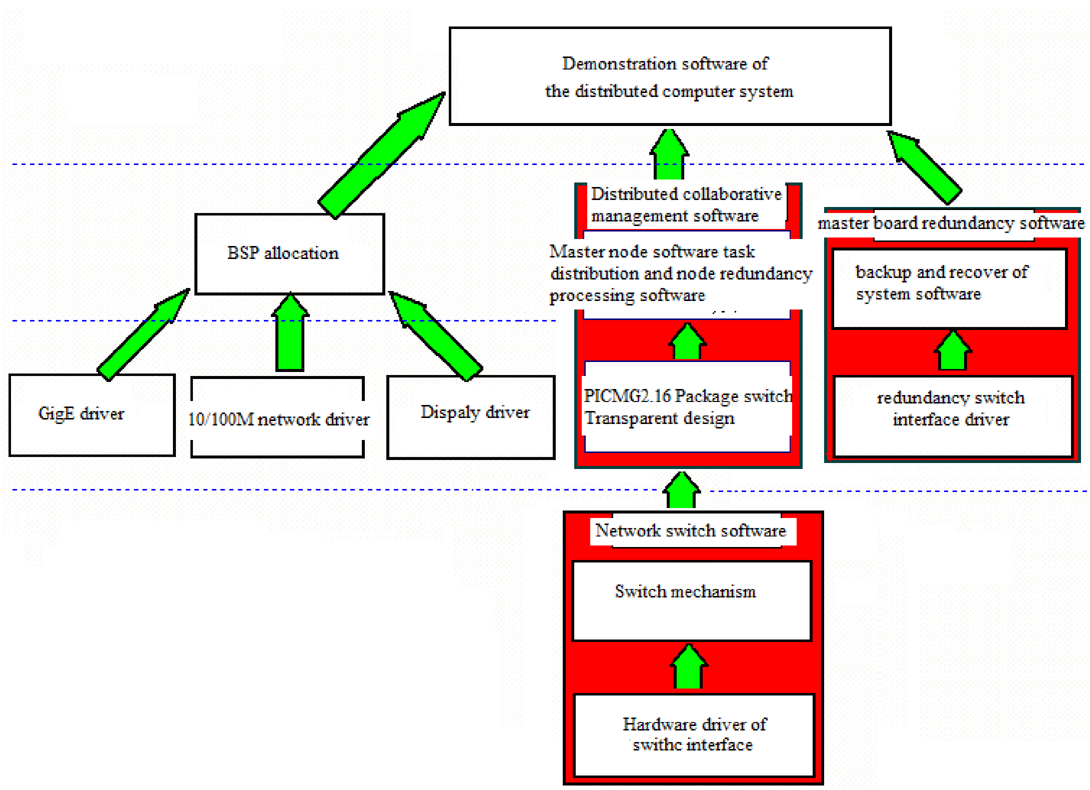

Figure 4. Architecture of the Integrated Data Processing Computer

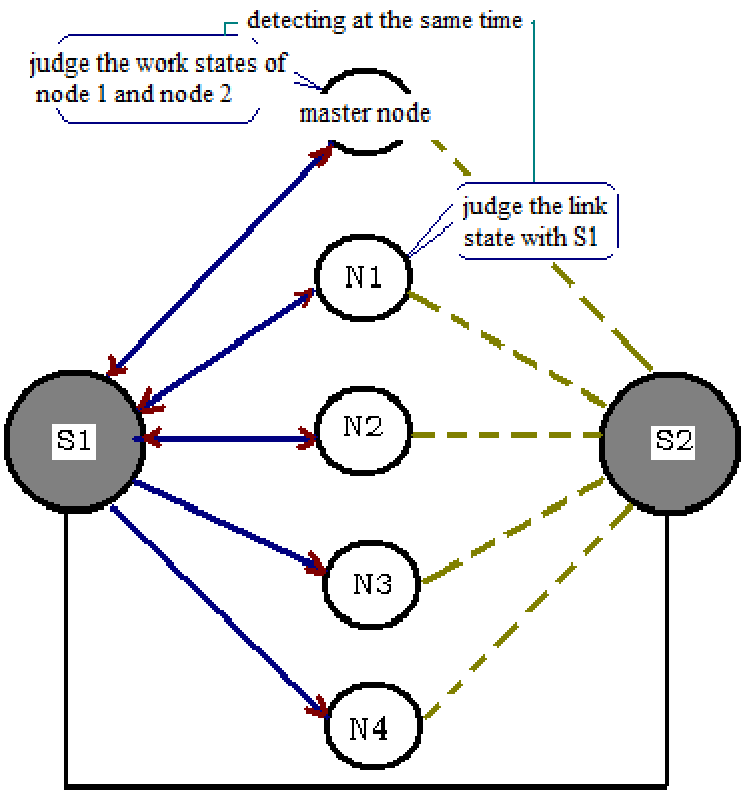

Figure 5. Detection Process of the Master Node

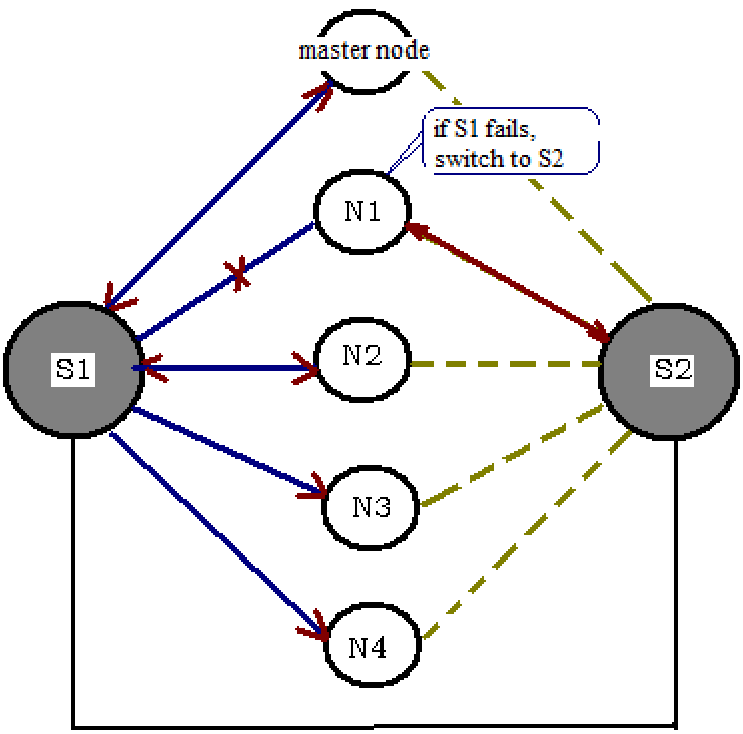

Figure 6. Work Process When the Node Failures

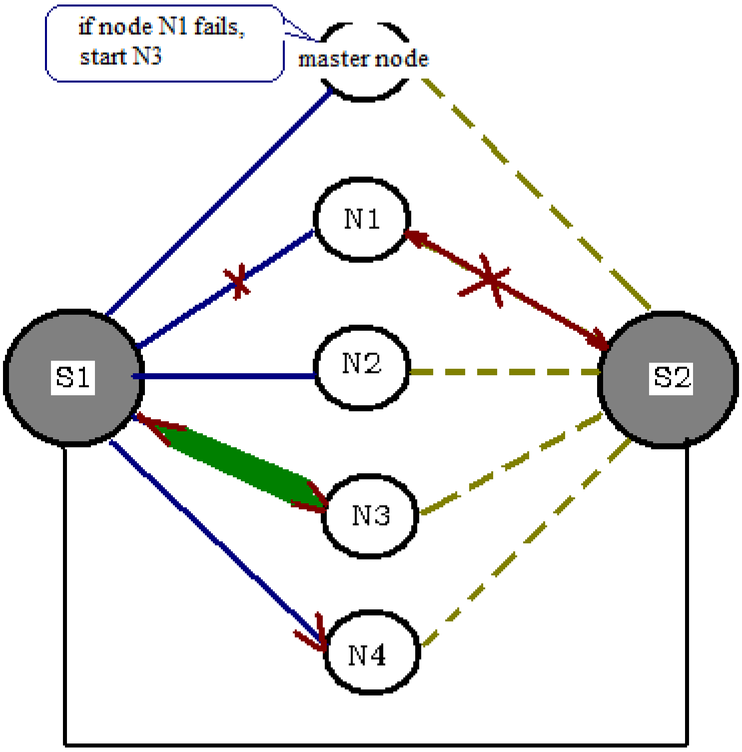

Figure 7. Work Process When the Switch or Link Failures

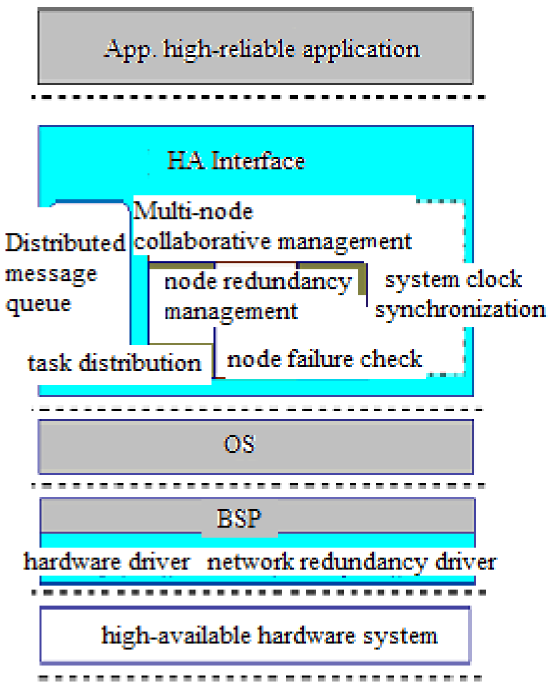

Figure 8. Architecture of the High-reliability Design of the system