1. Introduction
   In general, a fault tolerant system requires expert knowledge with high cost, and it is used for niche market currently.
   NEC Express5800/ft series is based upon Industrial standard IA server, Intel Pentium III Processor and Microsoft Windows2000 Advanced Server.
   This enables the system configuration and maintenance to be greatly simple and economical.

2. Mechanism of Hardware fault-tolerance
   A single NEC Express5800/ft series provides the duplication for CPU and PCI modules.
   The CPU modules are compared and synchronized with each other for parallel operation. If a fault occurs, NEC Express5800/ft series immediately disconnects the defected module at the detection of the fault and continues the processing by using the normal CPU module.
   The general I/O sections installed in the PCI modules are duplicated for the modules. If a fault occurs, NEC Express5800/ft series immediately disconnects the I/O section or entire module in which the fault occurs at the detection of the fault and continues the processing by using the normal I/O section or module.
   For hard disks, the software mirroring function included in OS provides the mirroring. NEC Express5800/ft series can have high reliability without specific array controller. SCSI controllers, disks, and internal bus from a controller to a disk are all duplicated in NEC Express5800/ft series. This enables NEC Express5800/ft series to continue the processing if a fault occurs in any of the SCSI controllers, disks, and internal buses.
   The fault tolerant chip set provides the above synchronization control, fault detection, disconnection, or recovery. The hardware duplication can have high availability without software intervention. Also, it allows system operations to be configured in the similar way as in a non-duplicate server.
   NEC Express5800/ft series is composed of the following components:

   - **CPU module**
     The CPU module includes a CPU and memory devices. NEC Express5800/ft series runs OS (Windows2000 Advanced Server) and applications by manipulating the CPU and memory.

   - **PCI module**
     The PCI module provides I/O processes including LAN, SCSI, and other I/Os.
     The PCI module is equipped with the SCSI controller and several PCI boards entirely.
     A specific board can be inserted into each of the PCI modules for board duplication.
• **Fault tolerant chip set**
  The fault tolerant chip set is intended to realize the fault tolerant function, the core of NEC Express5800/ft series. The features provided by the chip set include buffering and comparison between each pair of modules. The chips are distributed into modules.

• **Server Management Software**
  NEC ESMPRO Manager and Agent have the operation management functions specific for systems in NEC Express5800/ft series. NEC ESMPRO Manager and Agent, which have already achieved satisfactory results for the NEC Express5800/100 series, are newly provided with comprehensive operation management functions including operating status monitoring and manual module stop/start available for NEC Express5800/ft series. NEC Express5800/ft series does not use specific tools for the operation management. Instead, NEC ESMPRO executes all the functions on the operation management.

3. **Drivers, HAL**
   NEC Express5800/ft series contains the following functions specific for high availability.

   (1) **Reinforcement of dump acquisition function**
   If the system is terminated abnormally by hardware or software cause, only a single system acquires dump but the other system reboots in omission of dump. This allows restart time to be made shorter.

   (2) **Device driver**
   NEC Express5800/ft series use specific device drivers improving reliability and also being suit to duplication.

   (3) **Improvement of availability of BIOS and firmware**
   NEC Express5800/ft series can use tools started from NEC ESMPRO to update BIOS and some software products in the state that either of the systems is halted temporarily.

Figure: Hardware/software configuration in NEC Express5800/ft series
4. Operating system (Windows2000 Advanced Server)

From the viewpoint of the future scalability and the memory management/kernel protection, Windows 2000 Advanced Server providing the higher reliability than Windows 2000 Server. Windows 2000 Advanced Server is only supported OS in NEC Express5800/ft Server.

5. Structure of continuous operation

NEC Express5800/ft series contains major components in the multiplex way and also the fault tolerant function chipset controlling the operation of the multiplex hardware. If a fault occurs, NEC Express5800/ft series immediately disconnects the defective component from the system and continues the operation using the normal components. This allows the fault to have no influence on the system operation to continue services.

(i) CPU module (CPU and memory) failure

The fault tolerant function chipset properly compares the information of the multiplex CPU modules (CPU and memory) with each other to synchronize the operations and detect the occurrence of a fault in the clock level.

If a fault occurs, the fault tolerant function chipset immediately disconnects the defective CPU module from the system to continue the operation by using the normal CPU module. The chipset keeps the synchronization between the PCI modules. (i)

The defective CPU module can be removed physically and then repaired and reinstalled or replaced with new one while the system operation is continued. (ii)

When a normal CPU module is installed, the fault tolerant function chipset automatically enters into the resynchronization process. The chipset copies the memory data in the CPU module having continued the operation to the memory in the repaired or replaced CPU module. If the memory data in a CPU module becomes the same as that in another, the fault tolerant function chipset automatically returns to the synchronous operation. (iii)
(2) PCI module fault

For PCI modules (I/O) also, the fault tolerant function chipset synchronizes the modules with each other and detects the occurrence of a fault. If a fault occurs, the fault tolerant function chipset immediately disconnect the defective PCI module from the system to continue the operation by using the normal PCI module. The chipset keeps the synchronization between the PCI modules. (i) The defective PCI module can be removed physically and then repaired and reinstalled or replaced with new one while the system operation is continued. If the PCI board mounted on a PCI module is defected, remove the PCI module, replace the defective PCI board with new one, and install the PCI module again. (ii) When a normal PCI module is installed, the fault tolerant function chipset automatically enters into the resynchronization process. (iii)

![Diagram of PCI module fault](image)

Service execution/continuous operation

(3) Hard disk fault

If a hard disk itself is defected, OS automatically cancels the mirroring and continues the system operation by using the normal hard disk. (i) NEC Express5800/ft series contains hot-swap hard disks. The defected hard disk can be removed physically and then repaired and reinstalled or replaced with new one while the system operation is continued. (ii) After the reinstallation, the proper OS function (dynamic disk) returns the hard disks to the mirroring state while the system operation is continued. (iii)

![Diagram of hard disk fault](image)

Service execution/continuous operation

NEC Express5800/ft series 4
Hard disks are subject to data duplication by the software mirroring function provided by OS. Every hard disk is connected with the SCSI controller on each of the PCI modules. If either of the PCI modules (and the SCSI controller installed on it) is disconnected from the hard disks due to the occurrence of a fault, the normal PCI module continuing the operation are connected to all the hard disks. Accordingly, data mirroring can be continued.

(4) LAN controller fault

A normal LAN controller is installed in each of the PCI modules. Network connections (NIC) are started with the same MAC address. In the normal state, data transmission is carried out through the primary port. If the primary port is defected, the other PCI module detects the fault and then automatically switches to the secondary port at once to continue the operation. (i)
If a LAN controller is defected, remove the respective PCI module, replace the defected PCI board with new one, and install the PCI module again. (ii)
If a normal PCI module is installed, the fault tolerant function chipset automatically performs the resynchronization process for the PCI module. The LAN controller just built in is automatically returned to the system as the secondary component. (iii)

(i)

(ii)

(iii)

Service execution/continuous operation

(5) Power fault

NEC Express5800/ft series normally has the redundant power module configuration. Further, AC power is supplied to each power module through an independent AC power line. If either of the power modules is defected or cannot receive AC power, the other power module supplies proper power to NEC Express5800/ft series. (i)
NEC Express5800/ft series contains hot-swap power modules. The defected power module can be removed physically and then repaired and reinstalled or replaced with new one while the system operation is continued. (ii)
(6) Fan fault

Fans are installed in each of the CPU, PCI, and power modules. If a fan is defected, replace the module containing the defective fan with new one.
The fans installed in the CPU module cool the built-in hard disks.

Remarks

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