

NEC EXPRESSCLUSTER

System Construction Guide

NEC EXPRESSCLUSTER for Windows Ver 7.0

NEC EXPRESSCLUSTER for Windows Ver7.0

Introduction

Second Edition 05/26/2004

PREFACE

The "NEC EXPRESSCLUSTER/System Construction Guide" is intended for administrators who will construct cluster systems and for system engineers or maintenance personnel who will provide user support for these systems.

AUXILIARY INFORMATION

[Concerning the OS upgrade]

If an invalid procedure is used when upgrading the operating system of the cluster server, a failover may occur unexpectedly, or in the worst case, the system may be damaged.

This also holds for the application of service packs.

NEC EXPRESSCLUSTER Ver 7.0 FastSync™ Option

NEC EXPRESSCLUSTER Ver7.0 FastSync™ Option(called "FastSync Option" from now on) supports NEC EXPRESSCLUSTER LE Ver7.0.

Microsoft®, Windows®, and Windows NT® are registered trademarks of Microsoft Corporation. CLARiiON ATF and CLARiiON Array Manager are trademarks of EMC Corporation. Oracle Parallel Server is a trademark of Oracle Corporation. Other system names, company names, and product names are trademarks and registered trademarks of their respective companies.

NEC EXPRESSCLUSTER/System Construction Guide

Categories

The NEC EXPRESSCLUSTER/System Construction Guides are divided into separate volumes as follows according to the situations in which they are to be used and according to readers. If you are to construct a cluster system for the first time, please read "Introduction" first.

[Setup Card]

This is a reference card attached to the product, which describes the product configuration, operating environment, and so on.

[Introduction]

This is an introduction for someone who is to design and construct a cluster system for the first time.

[System Design (BASIC/Shared Disk, BASIC/Mirror Disk)]

This manual describes information necessary to install NEC EXPRESSCLUSTER and construct a system.

It explains necessary information and precautions concerning system construction.

There are two volumes, one for Shared Disk type and the other for Mirror Disk type.

[System Design (Application)]

This manual is a collection of knowhows for using advanced functions of NEC EXPRESSCLUSTER that are not described in System Design (BASIC).

[Cluster Installation and Configuration Guide (Shared Disk, Mirror Disk)]

This manual clearly explains environment settings to be made after installing NEC EXPRESSCLUSTER in the order that you will follow to build a cluster system.

There are two volumes, one for Shared Disk type and the other for Mirror Disk type.

[Operation/Maintenance]

This is a document that describes information required for operating a cluster system, how to deal with system failure, and lists of errors.

[GUI Reference]

This manual explains required concepts concerning NEC EXPRESSCLUSTER operation and describes how to operate NEC EXPRESSCLUSTER by using a graphical user interface (GUI) from a management client or a server.

[Command Reference]

This is a reference of commands that can be put in NEC EXPRESSCLUSTER scripts and maintenance commands that can be executed from the server's command prompt.

[For PP]

Every PP mentioned in this document can be executed in cooperation with NEC EXPRESSCLUSTER.

It explains settings, script writings, and some notes that are necessary to operate the PPs and NEC EXPRESSCLUSTER together.

Read carefully the respective PP edition for the PP you would like to use.

[Notes]

This reference describes items to be remembered in constructing, operating, and trouble shooting a cluster system. Read when necessary.

CONTENTS

1	NEC EXPRESSCLUSTER Overview	7
1.1	Effectiveness of cluster system implementation	7
1.2	Failure Monitoring and Failover	7
1.2.1	<i>Failure monitoring method</i>	<i>7</i>
1.2.2	<i>Monitorable/Unmonitorable failures</i>	<i>9</i>
1.2.3	<i>Failover mechanisms</i>	<i>10</i>
1.2.4	<i>Resolution of Network Partition</i>	<i>11</i>
1.2.5	<i>Failover Resources</i>	<i>14</i>
1.3	Cluster System Configuration and Operation	15
1.3.1	<i>System configuration</i>	<i>15</i>
1.3.2	<i>Operation forms of cluster</i>	<i>16</i>
1.3.3	<i>NEC EXPRESSCLUSTER Product Configuration</i>	<i>18</i>
2	Constructing a cluster system	19
2.1	System Overview	19
2.2	Steps for Designing a Cluster System	20
2.2.1	<i>Determining system configuration</i>	<i>20</i>
2.2.2	<i>Checking applications' adaptability to NEC EXPRESSCLUSTER</i>	<i>21</i>
2.2.3	<i>Designing a failover group</i>	<i>22</i>
2.2.4	<i>Script</i>	<i>23</i>
2.3	How to Increase Reliability	26
2.3.1	<i>Removing Single Point of Failure (SPF)</i>	<i>26</i>
2.3.2	<i>Detecting failures</i>	<i>27</i>
2.3.3	<i>Increasing reliability of post-failover</i>	<i>27</i>
3	Cluster system configuration and operation	28
3.1	Configuring a cluster system	28
3.2	Testing the system before the actual operation and creating a disaster recovery manual	29
3.2.1	<i>Identifying possible areas of error occurrence and testing based on simulated failures</i>	<i>29</i>
3.2.2	<i>Status transition evaluation</i>	<i>31</i>
3.2.3	<i>Adjusting Parameters</i>	<i>32</i>
3.3	Operating a cluster system	32
4	Advanced clustering	35
4.1	To achieve high-reliability	35
4.1.1	<i>Taking actions on application failures</i>	<i>35</i>
4.1.2	<i>Taking actions against hardware/partial OS failure</i>	<i>35</i>
4.1.3	<i>Server management board</i>	<i>35</i>
4.1.4	<i>LAN duplication</i>	<i>36</i>
4.1.5	<i>Disk path duplication</i>	<i>36</i>
4.2	Improving performance of your system	36
4.2.1	<i>Parallel Cluster</i>	<i>36</i>
4.3	Others	36
4.3.1	<i>NEC EXPRESSCLUSTER Client</i>	<i>36</i>
4.3.2	<i>NEC EXPRESSCLUSTER command</i>	<i>36</i>
4.3.3	<i>NEC EXPRESSCLUSTER API</i>	<i>36</i>
4.3.4	<i>Line switching device</i>	<i>37</i>
5	APPENDIX	38

5.1 Glossary 38

1 NEC EXPRESSCLUSTER Overview

In recent years, Windows platforms have been expanding their application areas due to their competitive cost performances. Since Windows server systems have been becoming more and more complicated and expanded, further availability and scalability are required. Under these circumstances, cluster systems are gaining the spotlight.

NEC EXPRESSCLUSTER is a middleware that supports cluster systems. The lineup provides a variety of products, ranging from highly available cluster systems at a low cost to highly scalable and highly available large cluster systems.

1.1 Effectiveness of cluster system implementation

What is a cluster system?

A cluster system operates multiple servers as a group to provide a highly available and scalable system, which cannot be achieved by a single-server system. The following benefits can be achieved through the implementation of the NEC EXPRESSCLUSTER.

* High availability

When one of the servers in a cluster system goes down due to a failure, another server will automatically take over the operations that the failed server had been operating. This minimizes the system downtime during failures.

* High scalability

With the ability to support up to 16 parallel databases, the NEC EXPRESSCLUSTER can provide for a highly available and highly efficient database platform.

1.2 Failure Monitoring and Failover

A cluster system monitors a variety of failures which may occur in a server, and transfers (fails over) the operations of the failed server to another in such an event.

1.2.1 Failure monitoring method

(1) Server monitoring

Monitoring servers is the most basic monitoring feature of a cluster system. It monitors servers in the cluster to check if any of them have stopped operating.

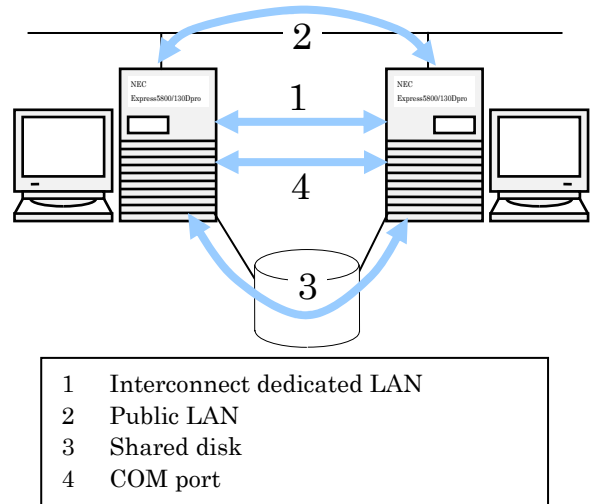
NEC EXPRESSCLUSTER performs continuity checks among the servers periodically for its server monitoring. This continuity checks, called “heartbeat”, is performed via the following four communication paths:

* Interconnect-dedicated LAN

A dedicated cluster system communication path, using standard Ethernet NICs. Used for performing heartbeat monitoring as well as communication between servers.

* Public LAN

A communication path used between servers and clients, and is used as a spare interconnect path. Any NIC can be used as long as it can support the TCP/IP protocol. In the event of an interconnect communication path failure, this path will be used for communication between servers.



* Shared disk

A dedicated NEC EXPRESSCLUSTER partition (CLUSTER partition), which is created on a disk of every server which constitute the cluster system. A heartbeat check is also performed on this CLUSTER partition.

When a failure occurs on other server, final checks will be performed through this disk to avoid data destruction, which may be caused by Network Partition syndrome (Split-brain-syndrome).

* COM port

Continuity checks between servers in a failover-type cluster system are performed through the COM port.

Communication here is used to resolve Network Partition syndrome.

What is Network Partition syndrome (Split-brain-syndrome)?

A failure of every network communication path of each cluster server causes a splitting from the network.

For detailed information, see “1.2.4 Resolution of Network Partition”. Cluster systems which are not Network Partition syndrome proof cannot distinguish the difference between communication errors and server errors, and may cause data corruption by accessing a single resource from multiple servers.

With these four communication paths, the reliability of communication between servers is increased dramatically. By performing this, you can prevent Network Partition syndrome.

(2) Application Monitoring

Application monitoring is a feature which monitors the continuity and potential failures of applications which may lead to an operation halt.

* Monitoring application services’ continuity

This monitoring can be performed by starting both applications and services using the “ARMLOAD¹” command of NEC EXPRESSCLUSTER. This will periodically monitor the continuity of processes and status of the services. This monitoring is effective when an operation is stopped due to an abnormal ending of an application.

¹ For more information on ARMLOAD command, see “NEC EXPRESSCLUSTER System Construction Guide / Command Reference”

<Notes>

Only applications and services that are started by NEC EXPRESSCLUSTER can be monitored using this function.

Errors occurring in resident processes, which other applications have started and ended, cannot be detected.

Errors within the applications themselves are not monitored.

Stalls and errors, which occur in applications, cannot be detected.

* Resource monitoring

“Resource Monitoring²” of NEC EXPRESSCLUSTER can be used to monitor cluster resources (such as disk partition, IP addresses) and status of the public LAN. This monitoring is effective when operations are stopped due to a failure of an essential resource.

(3) Internal Monitoring

This is a mutual monitoring among the modules in the NEC EXPRESSCLUSTER. Checks that each monitoring feature of the NEC EXPRESSCLUSTER is running without problems.

The following monitors are included in the NEC EXPRESSCLUSTER.

- * Mutual monitoring of NEC EXPRESSCLUSTER services and services monitoring process.
- * Stall monitoring of each type of heartbeat thread.

1.2.2 Monitorable/Unmonitorable failures.

(1) Server monitoring

Monitoring conditions: “Heartbeat” of a failed server stops.

- * Monitorable failures example
 - + Hardware failures (OS is unable to continue operations)
 - + STOP errors
- * Unmonitorable failures example
 - + Partial failures of the OS (such as mouse or keyboard failure)

(2) Application monitoring

Monitoring conditions: Termination of a failed application, continuous abnormal status of a resource, and disconnection of a path to a network device.

- * Monitorable failures examples
 - + An abnormal termination of an application.
 - + Failed access to shared disks (such as HBA³ failures).
 - + Malfunctions of a NIC used for the Public LAN.
- * Unmonitorable failures example
 - + Application stalls/irregular results

² For details on resource monitoring, see “*NEC EXPRESSCLUSTER System Construction Guide / System Design (Advanced)*” and “*NEC EXPRESSCLUSTER System Construction Guide / GUI Reference*”

³ Acronym for Host Bus Adapter. Referred to as the server side adapter and not the shared disk adapter.

1.2.3 Failover mechanisms

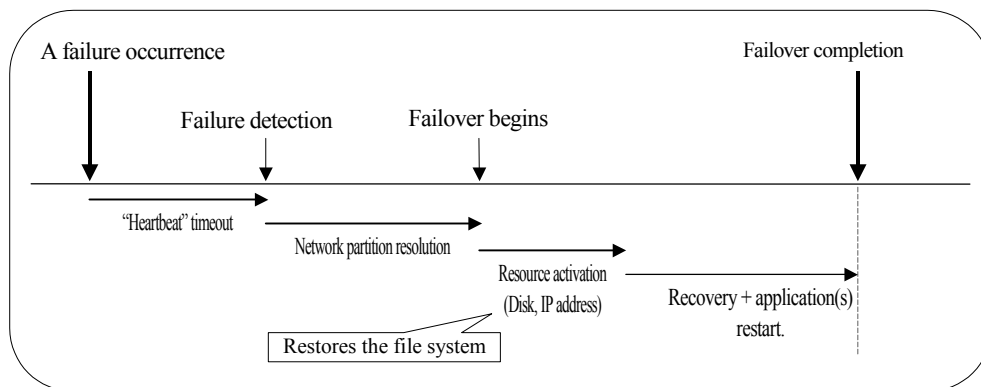
NEC EXPRESSCLUSTER distinguishes a server failure from a failure caused by Network Partition syndrome, before a failover is performed. After which each resource is activated and applications are started on an operable server to execute the failover.

A group of resources moved from the failed server to the operable server is called a failover group. From a user's standpoint, a failover group can be seen as a virtual computer

<Notes>

In a cluster system, failover is performed by starting applications on an operable server. Thus, process of status of application, which is stored in memory, cannot be failed over.

It takes several minutes from the occurrence of a failure to complete a failover process. See the following time chart.



- * Heartbeat timeout
 - + An interval of time from occurrence of a failure in the active server to when the standby server recognize the occurrence as an actual failure.
 - + Adjust the specified value of a cluster's property according to the load of the operations. (Default value: 30 seconds)

- * Resolution of Network Partition
 - + An interval of time for checking whether the detected failure has been caused by Network Partition syndrome or if a failure has actually occurred on one of the servers.
 - + Required time will vary according to the situation, such as access time to the cluster partition, or heartbeat timeout values. (Default value of the resolution: 30 to 60 seconds.)

- * Activation of resources
 - + An interval of time for activating operation-essential resources.
 - + It will only take several seconds with the standard settings. However, the time may vary according to the types and number of the resources registered in the failover group. For more information, see "*System Construction Guide / System Design (Basic)*".

- * Execution time of the Start script.
 - + An interval of time including both database recovery time such as rollback and roll-forward, and startup time of applications and/or services for the operations.
 - + An approximate value can be estimated for performing rollback and roll-forward, by adjusting checkpoint intervals. For details, see documents of each application program.

1.2.4 Resolution of Network Partition

Network Partition syndrome (Split Brain syndrome) is a situation in which every network between servers has failed so that each server has become isolated.

Cluster systems that are not Network Partition Syndrome compliant, will not be able to distinguish the difference between a failure in the network paths and a failure in the actual servers. This may cause data corruption due to multiple server accesses to a single resource. When NEC EXPRESSCLUSTER detects a heartbeat stop from one of the servers, it will confirm whether the failure is being caused by a server error or by a Network Partition syndrome. If it confirms that the failure is being caused by a server failure, it would perform a failover by activating resources on an operable server, to take over operations. If the failure is confirmed to be the result of a Network Partition syndrome, it will perform an emergency shutdown, because data protection is more important than server operations.

The following methods are resolutions for Network Partition syndrome.

- * COM method:
 - + Can be used in a two-node cluster.
 - + Serial cross cables are required.
 - + Judges whether or not an error is caused by a Network Partition syndrome, by performing heartbeat continuity checks using the COM communication paths.
 - + In cases when a server failure occurs while there are troubles in the COM communication paths (such as COM port, serial cross cable), a failover cannot be performed. This is due to the inability to resolve a Network Partition. All correctly operating servers will perform emergency shutdowns.
 - + In cases where the COM communication paths are working correctly, and the other network communication paths have failed, Network Partition is determined and all servers except for the highest priority server will perform emergency shutdown.
 - + In cases where COM communication paths (COM port, serial cross cable, and so on) have failed and all other network communication paths have also failed, every server will perform emergency shutdowns.
 - + In the worst-case scenario, that is, all network communication paths and COM communication paths in the cluster server have failed simultaneously, both of the servers will perform failovers. In such a case, a single resource is accessed by both servers which may cause data corruption.
- * Shared Disk method:
 - + Can be used in a cluster system which utilizes a shared disk.
 - + A dedicated disk partition (referred to as CLUSTER partition) is required on the shared disk.
 - + Distinguishes whether an error is caused by Network Partition syndrome, by writing data onto the shared disk periodically, to calculate the last-existence time of the other server.
 - + A failover cannot be performed in instances when a server fails while there are troubles in the shared disk or paths to the shared disk (such as SCSI bus). This is due to the inability to resolve a Network Partition. In such a case, an emergency shutdown of the other correctly operating servers will be performed.
 - + In cases when all network communication paths have failed while the shared disk is working properly, the problem will be distinguished as a Network Partition and a failover

will be performed among the top priority server and servers which can communicate with the top priority server. All other servers will perform emergency shutdowns.

- + In cases when all the network communication paths have failed while the shared disk and paths to the shared disk (such as SCSI bus) have also failed, every server will perform an emergency shutdown.
 - + In cases when the IO time to the shared disk takes longer time than the specified disk timeout, Network Partition resolution will time out, and failover may become disabled.
 - + The time required for Network Partition resolution is double the heartbeat timeout or double the disk IO waiting time, greater of the two.
- * COM + Shared disk method:
- + Can be used in a two-node cluster, utilizing a shared disk.
 - + Serial cross cables are required.
 - + A dedicated disk partition (referred to as CLUSTER partition) is required on the shared disk.
 - + In cases when one of the servers goes down while the COM communication path (COM port or serial cross cable) fails, the way to resolve the Network Partition syndrome is to switch from the COM method to the shared disk method..
 - + If all network communication paths fail although the COM communication path is working correctly; the situation will be determined as a Network Partition syndrome. In such a case, an emergency shutdown will be performed to the every server except for the highest priority server.
 - + In cases when all the network paths, including the COM communication path (COM port and serial cross cable), fail simultaneously, the way to resolve Network Partition syndrome is to switch from the COM method to the shared disk method.
 - + In the worst-case scenario, that is, all network communication paths and COM communication paths in the cluster server have failed simultaneously, both of the servers will perform failovers. In this case, at least one of the servers will perform an emergency shutdown, so that data corruption will be avoided.
- * Majority method:
- + Can be used in a cluster system consisting of three or more nodes.
 - + Avoids data corruption caused by Network Partition syndrome. A server that is unable to communicate with a majority of the servers due to a network error will go down.
 - + In cases when a majority of the servers is down, all other servers working properly will be shut down.
 - + In cases when all of the servers are isolated due to failure, such as in hubs, all servers will be shut down.
- * Data mirror method:
- + Can be used in a two-node cluster system utilizing data mirroring.
 - + In a data-mirroring environment, this method is automatically selected. All other Network Partition resolution methods will not be available.
 - + If every communication paths between the two nodes fail, both of the servers will perform failovers.
- * Not to resolve Network Partitions:
- + This is available in cluster systems where disk resources (Shared disk) are not utilized.
 - + If every communication paths between the cluster servers fail, every server will perform a failover.

The following table shows the recommended Network Partition resolution methods.

- Data mirroring method is automatically selected for data mirrored environments,
- The majority method is recommended for a cluster system comprised of three ore more

nodes.

- The COM + shared disk method is recommended for cluster systems which is comprised of two nodes and a shared disk.
- The COM method is recommended for cluster a system that is comprised of two nodes, without a shared disk.

Network Partition Resolution method	Number of nodes	Hardware Requirements	Cases when failover is not available	Cases when every network path is disabled	Cases when both servers will perform failovers.	Required time for Network Partition resolution
COM	2	Serial cable	COM error	All servers will be shut down.	COM failure occurrence while all network paths are disabled.	0
Shared disk	No limitation	Shared disk	Disk error	The highest priority server will remain in operation.	None	Calculated By checking the heartbeat timeout and disk IO wait time.
COM and Shared disk	2	Serial cable Shared disk	COM error	All servers will be shut down	None	0
Majority	More than 3	None	Majority of the servers are down	Servers that can communicate with a majority of the servers will remain in operation.	None	0
Data mirror	2	None	None	Both of the Servers will perform a failover.	When all the network paths are disabled.	0
Do not distinguish Network Partition	No limitation	None	None	ALL servers will perform a failover.	When all the network paths are disabled.	0

1.2.5 Failover Resources

NEC EXPRESSCLUSTER performs failover using mainly the following resources. The activation / deactivation of each during a failover is as follows:

- * Switched Partition
 - + A disk partition for storing data in which business applications must access before and after a failover.
- * Floating IP address
 - + By utilizing floating IP addresses to connect to the servers for operations, clients do not have to be aware of where (on which server) the operation are being performed, even in the event when the servers may have been changed due to a failover.
 - + Implemented by dynamically allocating IP addresses to the public LAN adapter, and adopting ARP packets. Floating IP addresses can be used on most of all the network devices to access server operations.

<Notes>

If a network device can update ARP tables by receiving ARP packets, floating IP address can be used on that device to access server operations.

- * Virtual Computer Name
 - + Virtual computer name (NetBIOS name) can be specified to connect to server operations.
 - + Implemented by using the dynamic adding/deleting feature of NetBIOS name. The virtual computer name can be used to connect to a Windows client. To connect from a remote LAN, a WINS server is required.
 - + In cases when a virtual computer name is used on Windows Server 2003, Windows XP, Windows 2000, Windows Me, and Windows 98, NEC EXPRESSCLUSTER Client may require installation.⁴
- * Script
 - + In the NEC EXPRESSCLUSTER, applications are started via scripts.
 - + Although, as a file system, files failed over as a shared disk may be correct, they may be incomplete as data. When a script is written, it is necessary to include application startup as well as recovery processes specific to the operations at the time of the failover.

⁴ For more information, see “*NEC EXPRESSCLUSTERPRO System Construction Guide / System design (Basic/Shared Disk)*” and “*NEC EXPRESSCLUSTERPRO System Construction Guide / System design (Basic/Mirror Disk)*”.

1.3 Cluster System Configuration and Operation

1.3.1 System configuration

(1) Shared disk system

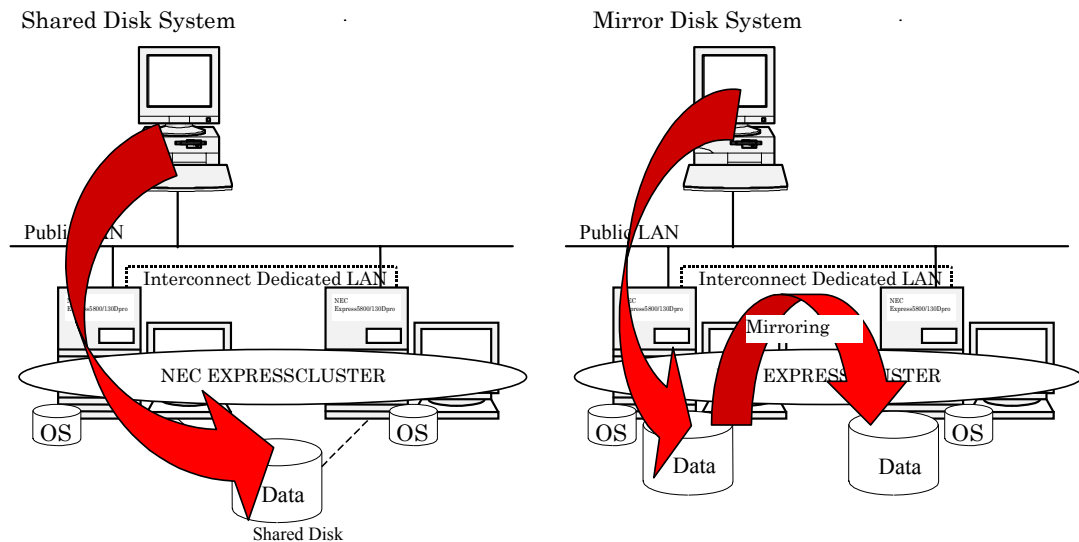
A configuration in which disk array devices are shared by cluster nodes. When an active server fails, the standby server will take over the operations utilizing data on the shared disk. In such a configuration, data capacity from tens of GB to several TB can be shared by using a shared disk.

(2) Mirror disk system (No shared disk)

A configuration in which data disks of cluster nodes are mirrored via network. No shared disk is utilized. When an active server fails, mirrored data on the standby server will become active to continue operations. Data mirroring is done in I/O increments, therefore this system may appear as a shared disk system from an upper applications' standpoint. 20 to 30 GB is the recommended capacity of disks in this system. This is due to the time required to rebuild the mirror after a failover recovery.

Mirror rebuilding

In a mirror disk system, if a failure occur on one of the servers or disks, there will be a discrepancy in the data after a server recovering. Mirror rebuilding will be performed to resolve this mismatched data on each mirrored server, after the server is recovered.

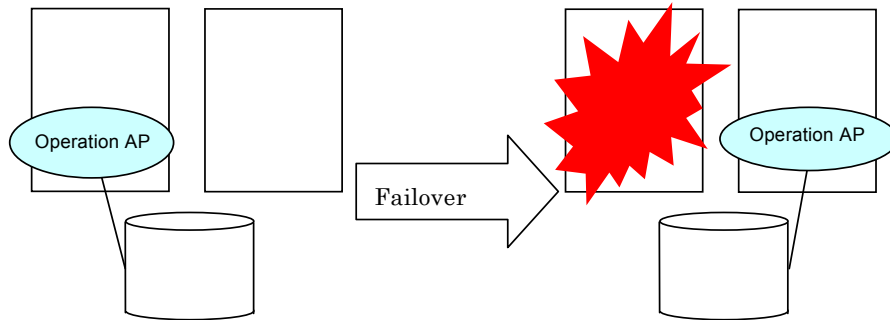


1.3.2 Operation forms of cluster

(1) Uni-directional Standby Cluster system

Specifies one of the servers as an active server running operations and tasks, and the other server as a standby server not running operations or tasks.

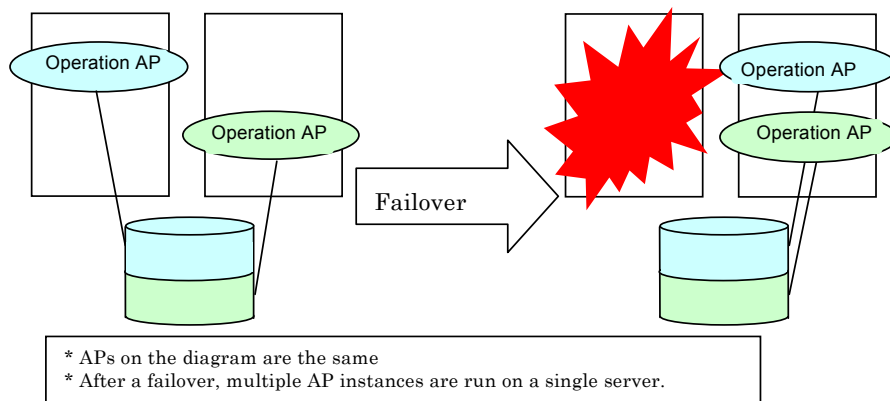
This is the simplest configuration in which a highly available system can be constructed, and which keeps the same performance even after a failover.



(2) Same application on multi-directional standby cluster

Operates same applications on multiple nodes and are mutually set as standby.

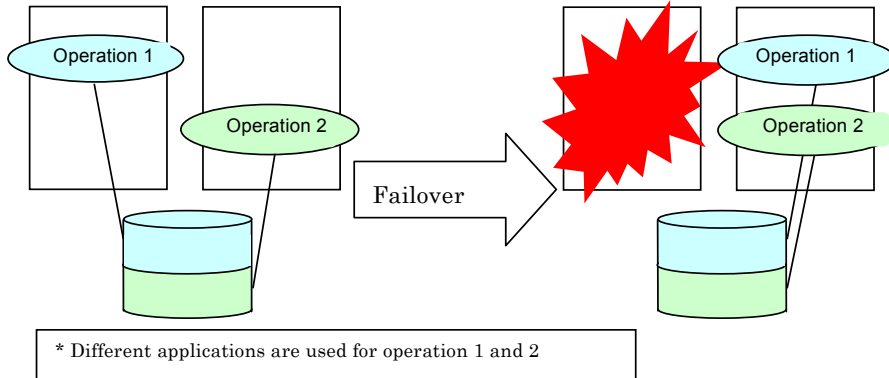
Applications used in this system must support multi-directional standby operations. In cases when data of an application can be divided into more than two, the destination from a client can be configured according to the data to be used. This makes it possible to configure a load-distributed system in data increments.



(3) Different applications on a multi-directional standby cluster

Operates different applications on different servers and are standby servers for each other.

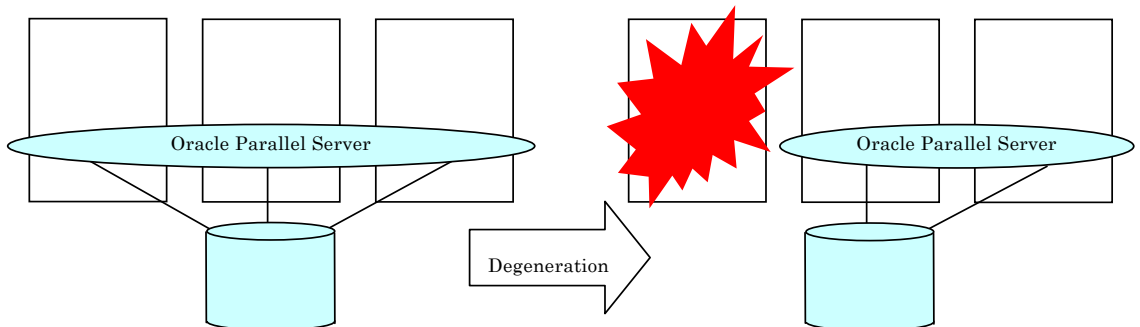
Applications in this system do not have to support multi-directional standby. A load-distributed system can be configured in operation increments.



(4) Parallel Cluster

Uses a parallel database engine (Oracle Parallel Server).

In this configuration, a single database can be accessed by any servers in the cluster system. If one of the servers fails, they will run in degenerative mode. In such a system, the combination of the ability to construct a load balancing platform system with database parallel queries (Oracle parallel query) allows for high performance database operations.



1.3.3 NEC EXPRESSCLUSTER Product Configuration

The NEC EXPRESSCLUSTER is released in a variety of versions, so that the most appropriate solution can be achieved depending on the scale of the user system.

		NEC EXPRESSCLUSTER LE	NEC EXPRESSCLUSTER SE	NEC EXPRESSCLUSTER EE	NEC EXPRESSCLUSTER SX
Scale of the system (Data Capacity)		Small-to-medium (20~30GB)*	Medium (Up to TB class)	Medium-to-large (Up to TB class)	Large (Up to TB class)
Disk		Mirror disk	Shared disk	Shared disk	Shared disk
Number of Servers		2	2	2~16	2~16
Operation configuration	O	O	O	O	O
	O	O	O	O	O
	O	O	O	O	O
	X	O	O	O	O
Supported PP		O	O	O	O

* 1 The amount of time required for mirroring and mirror rebuilding must be considered.

* 2 With NEC EXPRESSCLUSTER LE, when the FastSync Option (Extra-cost) is installed, the time required to rebuild a mirror may significantly be reduced.

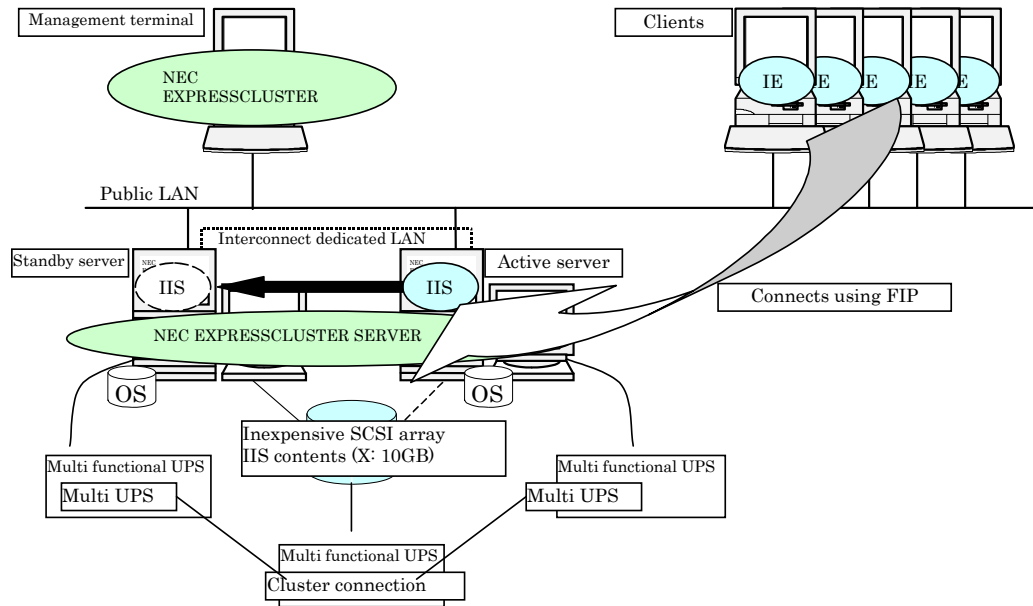
For more information concerning *1 and *2, see “NEC EXPRESSCLUSTER System Construction Guide / System design (BASIC/Mirror Disk)”.

2 Constructing a cluster system

2.1 System Overview

In this chapter, you will see notes of which you must take care when you construct a cluster system, with examining an actual example of system construction.

We will construct an information-providing WWW server using IIS, as a uni-directional standby cluster system.



2.2 Steps for Designing a Cluster System

2.2.1 Determining system configuration

(1) Hardware configuration

Determine hardware components required to your system based on both performance and disk space. The following diagram shows a configuration example using NEC products.

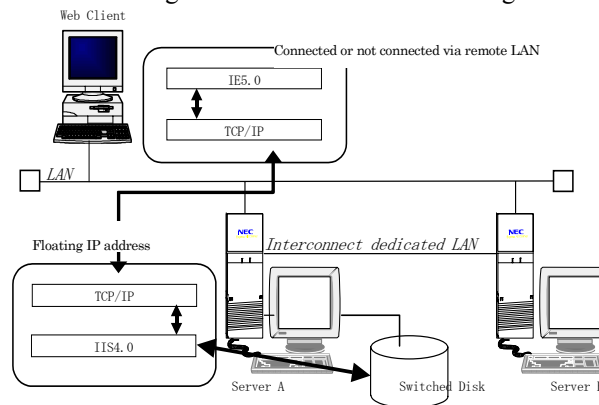
(2) Software configuration

Determine which version of NEC EXPRESSCLUSTER you should use based on the scale and form of the operations, and decide what applications you should choose.

The diagram below shows a configuration example using NEC products.

(3) Network and domain configuration

Determine a network configuration based on data flow diagram of the applications.



In the Active Directory environment of Windows 2000 or Windows Server 2003, cluster servers also need to belong to a single domain. It is not recommended to use a NEC EXPRESSCLUSTER server as a domain controller of the Active Directory.

2.2.2 Checking applications' adaptability to NEC EXPRESSCLUSTER

Check if the applications with which you are to construct your system are able to run on the NEC EXPRESSCLUSTER.

(1) Supported program products

With NEC EXPRESSCLUSTER, operation checks on most of major program products (PP) are already done, and construction methods and precautions based on these tests are released as reference information.

<Note>

Some features of applications and services may be restricted when they are used in a cluster system, and there are some precautions you have to take of.

For more information, see "*NEC EXPRESSCLUSTER System Construction Guide / [For PP]*".

Operation checks are done on the following PPs and others.

- + IIS (Internet Information Server) Version 4.0/5.0
- + Exchange Server 5.5 Enterprise Edition
- + SQL Server Version 6.5/7.0
- + Oracle R7.3.4/8.0.x/8.1.5
- + ARCserve
- + Backup Exec
- + NEC ESMPRO/Server Agent, NEC ESMPRO/Manager

(2) Other applications

In case you use a PP that is not tested yet, or an application that you have just created, you can apply it to a cluster system by creating a script for the application.

<Notes>

Depending on types or characteristics of the applications you are to operate on a cluster system, some of them may not be able to be operated on a cluster system.

For details, see Chapter 4 “APPLICATIONS AND SERVICES IN AN NEC EXPRESSCLUSTER ENVIRONMENT” of “NEC EXPRESSCLUSTER System Construction Guide / System Design(Basic)”

2.2.3 Designing a failover group

Design a failover group with the precautions listed below.

- + Guidelines to determine a failover group unit.
 - = Make a set of applications/resources, which are dependent each other, as a group.
 - = Make a group by each operation.
 - = Make a group by load-distributed system.
- + Consider your failover policy
 - = Confirm the post-failover system requirements of the servers.
 - = Register minimum number of servers, which are required to be destinations of failover, to a failover policy.

What is a failover policy?

Attributes that are specified for a failover group: A priority list of registered servers as destination of failover.

NEC EXPRESSCLUSTER controls destination servers according to this priority list.

For example, you are to construct a failover group just like described in the following table, for an information providing failover group of IIS.

Failover group name	IIS	
Resources	Switched Partition	X: (NTFS – 10GB)
	Floating IP address	192.168.0.3
Failover policy	SERVER1 → SERVER2	

2.2.4 Script

Create scripts referencing to “*System Construction Guide / [For PP]*”.
With the Script Easy Creation, you can create a script easily.

Script example:

(Start Script: for IIS uni-directional standby system, to perform application monitoring with ARMLOAD and resource monitoring with ARMRSP)

```
REM START.BAT
REM GROUP NAME=IIS: FAILOVER_POLICY=SERVERA->SERVERB
REM DATE: 2000/01/31 REV1
IF "%ARMS_EVENT%" == "START" GOTO NORMAL
IF "%ARMS_EVENT%" == "FAILOVER" GOTO FAILOVER
IF "%ARMS_EVENT%" == "RECOVER" GOTO RECOVER
GOTO NO_ARM
```

```
:NORMAL
ARMLOAD RSP /R 9 /H 1 /FOV ARMRSP /A
```

Monitors resources of the cluster.

```
IF "%ARMS_DISK%" == "FAILURE" GOTO ERROR_DISK
```

```
ARMLOG "NORMAL START IIS GROUP SCRIPT"
ARMLOAD WWWPS /S /M "W3SVC"
ARMLOG "WWW STARTED"
GOTO EXIT
```

Performs continuity checks on the application.
Debugs the script easily by outputting logs with ARMLOG each time the application starts.

```
:FAILOVER
ARMLOAD RSP /R 9 /H 1 /FOV ARMRSP /A
```

```
IF "%ARMS_DISK%" == "FAILURE" GOTO ERROR_DISK
```

```
ARMLOG "FAILOVER START IIS GROUP SCRIPT"
ARMLOAD WWWPS /S /M "W3SVC"
ARMLOG "WWW STARTED"
GOTO EXIT
```

If you do not need an explicit recovery process after a failover, describe the same as the normal startup.

```
:RECOVER
ARMLOG "RECOVER START IIS GROUP"
GOTO EXIT
:NO_ARM
ARMLOG "ERROR NO_ARM IIS GROUP" /ARM
GOTO EXIT
:ERROR_DISK
```

```
ARMLOG "ERROR DISK IIS GROUP" /ARM
```

```
start diskfail.bat
```

Process Overview :
Process required when a disk failure occurs.

```
:NOARM
GOTO EXIT
```

```
:EXIT
```

```
rem *****  
rem *          diskfail.BAT          *  
rem *****  
  
IF "%ARMS_SERVER%" == "OTHER" GOTO EXIT  
  
START ARMFOVER /F %ARMS_GROUPNAME%  
  
:EXIT  
exit
```

If it fails to connect to the disk, try to perform a failover to the standby server.

Script Example:

(Stop Script: for IIS uni-standby system, to perform application monitoring with ARMLoad, and resource monitoring with ARMRSP)

```
REM STOP.BAT
REM GROUP NAME=IIS: FAILOVER_POLICY=SERVERA->SERVERB
REM DATE: 2000/01/31 REV1
IF "%ARMS_EVENT%" == "START" GOTO NORMAL
IF "%ARMS_EVENT%" == "FAILOVER" GOTO FAILOVER
GOTO NO_ARM
```

```
:NORMAL
ARMKILL RSP
```

Quit applications, which has been started with ARMLoad, by using ARMKILL.

```
IF "%ARMS_DISK%" == "FAILURE" GOTO ERROR_DISK
```

```
ARMLOG "NORMAL STOP IIS GROUP SCRIPT"
ARMKILL WWWPS
ARMLOG "WWW STOPPED"
GOTO EXIT
```

```
:FAILOVER
ARMKILL RSP
```

```
IF "%ARMS_DISK%" == "FAILURE" GOTO ERROR_DISK
```

```
ARMLOG "FAILOVER STOP IIS GROUP SCRIPT"
ARMKILL WWWPS
ARMLOG "WWW STOPPED"
GOTO EXIT
```

```
:NO_ARM
ARMLOG "ERROR NO_ARM IIS GROUP" /ARM
GOTO EXIT
:ERROR_DISK
GOTO EXIT
```

```
:EXIT
ARMLOG "END IIS STOP SCRIPT"
```

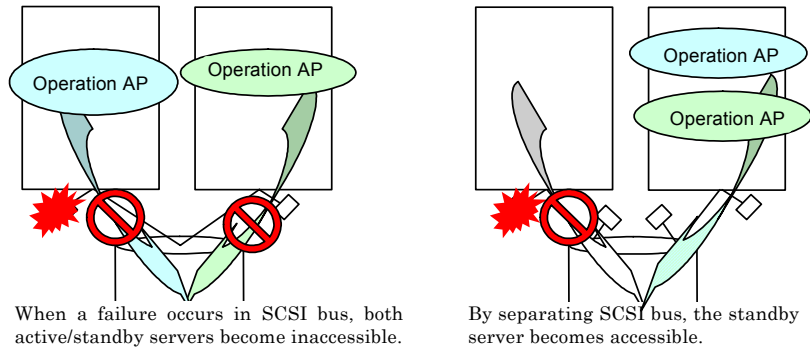
2.3 How to Increase Reliability

2.3.1 Removing Single Point of Failure (SPF)

Although a cluster system can team servers for fault-tolerance, there are still resources not shared by servers such as a shared disk. You can increase the reliability of your cluster system by multiplexing or removing these shared parts.

- * SCSI bus/FibreChannel of a shared disk and controller.
 - Mirror disk ->Not shared.
 - SCSI bus partitioning + disk resource monitoring (Failover with ARMRSP) ->Perform a failover to other node.
 - Retry the operations which had been running when the failure occurred.
 - SCSI/FibreChannel duplication (With path switching) ->Switch to an operable path
 - Operations continues.

In case SCSI bus become SPF



- * LAN for connecting to clients
 - LAN's teaming for fault-tolerance. ->Switch to an operable path.
 - Retry the operations which had been running when the failure occurred.
- * Other shared device
 - Can be duplicated. ->Duplicate devices.
 - Cannot be duplicated. ->Design a system so that the entire system, including operations that do not use the shared devices, will not stop due to a failure of the shared devices.

What is a Single Point of Failure (SPF)?

Part of a system, a failure of which will cause the entire system to be stopped. A typical example in a cluster system is the access path to the shared disk which is shared among servers.

2.3.2 Detecting failures

Design a system which can detect failures which may stop the operation and status where the operation cannot continue as soon as possible.

- * Hardware failures
 - + Detection and notification of failures before an error cause a double failure.
(Ex: Failures that occur on two or more array disks in a RAID configuration)
 - + Detection of failures which will not trigger a failover, and performing a failover.
With NEC ESMPRO/ ServerAgent, you can monitor event logs that may indicate potential errors, and perform a failover if necessary.
(For more information, See “*NEC EXPRESSCLUSTER System Construction Guide / System Design (Application)*”)
- * Software failures
 - + Detection of application failures and then performing a failover.
Use the ARMLOAD command, or make an application for monitoring. If an error occurs, perform a failover.
(For details, see “*System Construction Guide / system design (Application)*”)

2.3.3 Increasing reliability of post-failover

Design a system in which applications will work properly after a failover.

Operation form	Check point
Uni-directional Standby Cluster	Do specifications of the standby server, such as CPU performance and memory capacity, meet required criteria?
Same AP on multi-directional standby cluster	Do specifications of the servers meet required criteria to perform multiple tasks? Are there any problems in the operations of applications after performing a failover?
Different AP on multi-directional standby cluster	Do specifications of the servers meet required criteria to perform multiple tasks? Are there any problems in compatibility among applications after performing a failover?

3 Cluster system configuration and operation

3.1 Configuring a cluster system

The followings are configuration methods and precautions for cluster system configurations. For more information about installation procedures and of settings, refer to an appropriate guide, such as setup card, of the application you are to use.

(1) OS Installation

Install the OS on each server. Note the following.

- * Apply Service Pack.
- * Cluster servers must belong to the same domain.
- * Install SNMP service.
- * Change property of server service to “Maximize throughput of network application”.
- * Do not bind any other protocols than TCP/IP on adapters of the interconnect- dedicated LAN.
- * Adjust the times for synchronization.



(2) Installation of NEC EXPRESSCLUSTER

a) NEC EXPRESSCLUSTER Server

- * Install NEC EXPRESSCLUSTER on the cluster servers.
- * Specify the disk you are to use as the shared disk (X-CALL).
- * Create partitions on the shared disk.
- * Specify a drive letter/cluster letter to the partition.
- * Adjust the OS startup time.
- * Set the startup of NEC EXPRESSCLUSTER Server service as automatic.



b) NEC EXPRESSCLUSTER Manager

- * Install NEC EXPRESSCLUSTER Manager on the management terminal.



c) Perform the [Create cluster] - [Add server] - [Add group]

- * Perform this with NEC EXPRESSCLUSTER Manager



(3) Installation of the necessary business applications.

- * Install necessary user applications (See “*System Construction Guide / [For PP]*”)

3.2 Testing the system before the actual operation and creating a disaster recovery manual

Before the actual operation, perform tests to check and modify the scripts and parameters, with consideration of workload and potential failures in actual operation. Create manuals, which show how to recover from failures, based on the results of the tests.

3.2.1 Identifying possible areas of error occurrence and testing based on simulated failures

Identify possible areas of error occurrence for testing based on simulated failures. For example, areas at which errors would take place described in the following table.

Failed area		Main failure	Operation's durability
Main server		CPU failure (OS STOP error)	Δ1
		Failure on Display/Keyboard/Mouse	O
Shared disk *Only in shared disk systems	Disk array device	Failure on a single HDD	O
		Failures on more than one HDD	X
		Controller failure	Δ2
	SCSI/FibreChannel	Cable failure, Terminal failure, HUB/Switch failure	Δ2
	HBA (Host Bus Adapter)	Adapter failure (OS Stopping error)	Δ1
		Adapter failure (I/O error)	Δ3
UPS		Failure in UPS for server/RS232C	O
		Power failure in UPS for server	Δ1
		Failure in UPS for shared disk/RS232C	O
		Power failure in UPS for shared disk	X
		All UPS power failure	X
LAN	Interconnect LAN	NIC failure	O
		Cable failure, HUB/Switch failure	O
	Public LAN	NIC failure	Δ4
		Cable failure, Port failure in HUB/Switch	Δ4
Software		OS STOP error	Δ1
		Application halt	Δ5
		Application stall	Δ6

O: Operations can continue.

Δ: You may continue the operations with some features of NEC EXPRESSCLUSTER or features of hardware.

X: Operations can not continue.

Δ1: Failover is performed and the standby server takes operations over.

Δ2: Operations can continue via the operable path by duplicating the path to the shared disk.

Δ3: Detects errors in disk resources by using resource monitoring or NEC ESMPRO/ ServerAgent to perform a failover. The standby system takes over the operations.

Δ4: Detects errors in the LAN by using resource monitoring or NEC ESMPRO/ ServerAgent to perform failovers. The standby system takes over operations.

Δ5: Detects failures in the applications by using ARMLOAD command to perform failovers. The standby system takes over operations.

Δ6: Create an application to detect stalls in each application, so that the system can perform failovers

and the standby system can take over operations.

3.2.2 Status transition evaluation

Specify items according to the actual operation to perform status transition evaluation of cluster systems. The following table lists some examples in two-server cluster systems.

Evaluation items		Operation	Check point
Startup	Starts the cluster.	Start both of the servers.	Both of the servers and all failover groups start properly.
	Starts active server only.	Start the active server only.	A failover group starts after it has waited five minutes for the startup of the standby server after OS startup.
	Starts standby server only.	Start the standby server only.	
Shut down		Shut down the cluster (With NEC EXPRESSCLUSTER Manager).	Check that all servers are properly shut down and the servers and failover groups work properly after being restarted. In case you use UPSs, check that the power supply to the UPSs are also cut when you shut down the servers.
Failover	Server isolation.	Isolate the active server from a cluster (With NEC EXPRESSCLUSTER Manager).	Check that the active server is isolated from the cluster, that the system performs a failover properly, and that operations continue properly.
	Server shut down.	Shut down the active server from START menu	
	Cut off the power supply to the server.	Cut power supply to the active server off (Without performing shut down)	
Failover group	Move a failover group.	Move, stop, and start a failover group (With NEC EXPRESSCLUSTER Manager).	Check that the failover group has moved to the standby system and it can keep the operations after the change.
	Stop a failover group.		Check that isolation of the switched partition is done properly.
	Start a failover group.		Check that the failover group starts properly and it can start operations after the startup.
Disaster recovery	Recovery from one server down.	Return an isolated server to the cluster (With NEC EXPRESSCLUSTER Manager).	Check that the server is included in the cluster to become the standby server.
	Recovery from the servers down.	Forcibly return the proper server to the cluster, and return the other server to the cluster. (With NEC EXPRESSCLUSTER Manager).	The cluster becomes normal status. At this point the failover group is stopped.

3.2.3 Adjusting Parameters

You have to adjust the following items according to your system configuration.

Items	How to adjust
Heartbeat timeout	Simulate a maximum workload that would take place in actual operation to a server (To confirm that the server will not perform unnecessary failover under these situations). Determine if the heartbeat timeout works when disk path switching occurred at a failover.
Grace time for startup synchronization	Measure differences among startup time of all servers.
Disk IO latency.	Specify your predicted latency time for re-accessing the shared disk after a server failed. For example, specify 80 seconds or more in case of FC connection with the shared disk (such as NEC FibreChannel disk or iStorage disk) to a server.
Script timeout	Measure the maximum run time of the scripts.
OS startup time	Specify the maximum startup time of the shared disk.

3.3 Operating a cluster system

This section describes how to operate a cluster system and precautions for that. For more detailed operation method for NEC EXPRESSCLUSTER Manager, refer to the “*NEC EXPRESSCLUSTER System Construction Guide / GUI Reference*”

(1) Starting a cluster

* Manual startup

+ Configure the AUTO/LOCAL switch of multi-functional UPS to LOCAL, and power the UPS on.

= If it is set as LOCAL, it will not work automatically. Set the AUTO/LOCAL switch to AUTO to return to automatic operation.

(2) Cluster shutdown

- * Manual shutdown
 - + With NEC EXPRESSCLUSTER Manager, select the cluster you want to shutdown and shut it down.
 - = You have to configure the AUTO/LOCAL switch of the multi-functional UPS as AUTO.

<Notes>

When AUTO/LOCAL switch of the multi-functional UPS is set as LOCAL, only services of NEC EXPRESSCLUSTER would be stopped, and the OS would not be shut down. Set the switch to AUTO to shut down the OS.
Keep the switch as AUTO except for maintenances.

(3) When the active system is down

- * In cases when NEC EXPRESSCLUSTER success in performing an automatic failover.
 - + When the active server is down, NEC EXPRESSCLUSTER Manager displays the server's icon in red, and then NEC EXPRESSCLUSTER will automatically execute a failover.
- * In cases when NEC EXPRESSCLUSTER failed to perform an automatic failover.
 - + There are some cases that NEC EXPRESSCLUSTER cannot execute automatic failover because some functions of the OS or an application have stalled. In these cases, shut down the server by using the shutdown command on the start menu of the active server or by pressing the dump switch on the server. Then NEC EXPRESSCLUSTER will recognize that the server is down and will execute a failover.
 - + At this time, turn the failed server's power off if you can do so.

(4) Returning the failed server

NEC EXPRESSCLUSTER automatically isolates the failed server from the cluster after you restart the server. To set the server as a standby server again, you have to return it to the cluster after removing the cause of the failure.

With NEC EXPRESSCLUSTER Manager, return the isolated server to the cluster.

<Notes>

After the server was isolated from the cluster, the server still keeps doing communication for status checks of NEC EXPRESSCLUSTER.
Therefore, if you want to do maintenance to a server-connected part, such as a network or a HBA, physically detach the device from the cluster system.

(5) Server maintenance (Rolling upgrade)

In server maintenances for such as adding memory, you can minimize the potential system downtime by upgrading each server one by one (rolling upgrade).

Follow steps below.

- (1) Isolate the standby server from the cluster.
With NEC EXPRESSCLUSTER Manager, select the standby server to isolate it.
- (2) Add the memory to the standby server, and then restart it.
- (3) Return the standby server to the cluster.
With NEC EXPRESSCLUSTER Manager, select the standby server to return it to the cluster.
- (4) Move the failover group
With NEC EXPRESSCLUSTER Manager, move the failover group, which is running on the active system to the standby system.
- (5) Isolate the active server from the cluster.
- (6) Add a memory device to the active server and then restart the server.

<Notes>

When you perform rolling upgrade of software, errors may occur due to the temporary mismatch of the software revision in the servers.
Perform rolling upgrade after you confirm that there would not be compatibility problem in data on the shared disk.

(6) Recovering from all-server down

In cases when all of the servers are down, NEC EXPRESSCLUSTER cannot decide which server has the reliable cluster information, so that it cannot return any server to the cluster.

To perform a recovery from this situation, follow the steps below.

- (1) With NEC EXPRESSCLUSTER Manager, select the server you want to use as base of cluster information, return the server to the cluster forcibly.
- (2) With NEC EXPRESSCLUSTER Manager, return the remaining servers to the cluster.
- (3) With NEC EXPRESSCLUSTER Manager, start the failover group.

4 Advanced clustering

4.1 To achieve high-reliability

4.1.1 Taking actions on application failures

To take actions on failures to which you cannot apply the ARMLOAD command, such as application stalls and abnormal results, create a program, which can monitor the status of applications, with consideration for each application's internal specifications.

For example, you can monitor database stalls by accessing the database periodically and if the database does not seem to respond for some specific period of time, shut down the server because the database may have stalled. In addition, application that appears consuming an abnormally large amount of memory or disk space can be monitored, and the failover group can be moved accordingly.

These monitoring programs can use the NEC EXPRESSCLUSTER commands (ARMDOWN/ARMFOVER) to perform server shutdowns and failovers. For details, see "*System Construction Guide / System Design (Application)*"

4.1.2 Taking actions against hardware/partial OS failure

Some hardware failures output warnings or abnormalities to event logs. By monitoring these logs, you can set these failures, which NEC EXPRESSCLUSTER cannot detect, as targets for performing failovers.

You can make this possible by detecting hardware failures and making NEC EXPRESSCLUSTER perform failovers by using the following method.

- * Failure monitoring with NEC ESMPRO/Server Agent.
- * Orders from NEC ESMPRO/ Manager to perform failovers at the event of failures.

By using the same methods, you can avoid system downtime by monitoring resources such as memories and disk spaces, to detect potential errors and perform failovers before the OS fails.

For detailed information, see "*System Construction Guide / System Design (Application)*"

4.1.3 Server management board

In a shared disk system (a shared disk type cluster system), more than one server are sharing SCSI buses. Therefore, if a SCSI adapter (HBA) fails and disturbs other buses with noise when a failure occurs, NEC EXPRESSCLUSTER may fail to perform a failover. Even if it succeeds to do so, the standby system may fail to access the shared disk and operations may also fail.

In such a case, you can cut off the power supply to the failed server by using the server management board (SMB)

See "*NEC EXPRESSCLUSTER System Construction Guide / System Design (Application)*" for details.

Note that NEC's server management board (N8503-33 Server management board) or equivalent server management board is required to apply these features.

4.1.4 LAN duplication

By configuring more than one path between a client and servers, LAN duplication is a method in keeping operations running when one of the network paths fails. See “*NEC EXPRESSCLUSTER System Construction Guide / System Design (Application)*” for details.

4.1.5 Disk path duplication

Duplicates the access path to the shared disk.

To do so, add a dual port device on the shared disk, and use path-switching software.

For details, see “*System Construction Guide / System Design (Application)*”.

4.2 Improving performance of your system

4.2.1 Parallel Cluster

With Oracle Parallel Server (OPS), you can configure a parallel database engine which allows simultaneous accesses to a single database from multiple servers. OPS also allows you to easily configure highly-available and highly-scalable distributed-processing applications. In addition, by using Oracle Parallel Query (OPQ), you can perform parallel retrievals at high-speeds.

For more information on OPS, see “Oracle Parallel Server System Construction Guide”.

4.3 Others

4.3.1 NEC EXPRESSCLUSTER Client

During normal operations with NEC EXPRESSCLUSTER, you do not have to install NEC EXPRESSCLUSTER modules onto your client PC.

However, installing the NEC EXPRESSCLUSTER Client on a client PC will allow the user to know the occurrences of a failover, via a pop-up message on the client PC screen.

In addition, in cases you set duplicated public LAN, you can switch LAN’s paths automatically by installing NEC EXPRESSCLUSTER Client.

See “*NEC EXPRESSCLUSTER System Construction Guide / System Design (Application)*” for details.

4.3.2 NEC EXPRESSCLUSTER command

NEC EXPRESSCLUSTER provides you with various commands. ARMLOAD is a command for attaining high-availability. There are also commands to create scripts easily for failover groups, and commands for managing a cluster system.

In case when virtual computer names are used, NEC EXPRESSCLUSTER Client installation may be required.

For more information, see “*NEC EXPRESSCLUSTER System Construction Guide / Command Reference*”

4.3.3 NEC EXPRESSCLUSTER API

With NEC EXPRESSCLUSTER API, you can create an application, which monitors the status of your cluster system and behaves (referred to as Cluster-Aware AP). This allows you to develop a client application that performs its re-connection automatically with proper timing according to the status of the cluster transition.

4.3.4 Line switching device

In cases when lines such as V.24 and X.21 are used in cluster systems, you are to use line-switching (LSW) devices.

By registering line resources in failover groups, you can switch the lines as a group to the other server in your cluster system.

See “*NEC EXPRESSCLUSTER System Construction Guide / System Design (Application)*” for details.

To use these features, NEC’s line switching devices (N8591-01/02 V.24/X.21 LSW device, N8545-01/03 V.24/X.21 LSW unit, N8545-02/04 V.24/X.21 LSW expanded unit), or equivalent LSW devices are required. In addition, NEC’s high-speed multi-line board (N8104-102 high-speed multi-line board) or equivalent high-speed multi-line board is required.

5 APPENDIX

5.1 Glossary

Term	Description
A	
active system	A server unit in which active operations are running. (Related term) standby system.
Aware AP	An application created using NEC EXPRESSCLUSTER API. To be used in conjunction to NEC EXPRESSCLUSTER.
C	
CLUSTER partition	A partition used by the NEC EXPRESSCLUSTER, for monitoring the other server. (Related term) shared partition, switched partition
cluster system	A set of connected computers, using such as LAN, so that they can behave as if it were a single system.
cross call disk	A disk that can be accessed by more than one server. (Related term) shared disk.
F	
failover	A transfer of application's operations from the active server to the standby server.
failback	To restart both of the servers after a failover, to return operations to the original active server (used in only Ver3.0)
failover group	A group of resources and attributes that are essential to performing operations.
failover group migration	To carry out a failback without restarting both of the server.
failover policy	A list of servers that can be failed over, with their priority attributes.
FastSync Option	An optional product used by cluster systems configured with NEC EXPRESSCLUSTER LE/LX. It can lessen the time of mirroring by restoring only differences in data.
floating IP address	An IP address; If this is used, clients do not have to be aware of switching of servers it is connecting even in the event of failover. Assign a host address not in use within the network address to which the cluster system belongs.
H	
heartbeat	A mutual communication signal between servers for monitoring. (Related term) interconnect, Network Partition
I	
interconnect	A communication path used only for communication between servers. (Related term) private LAN, public LAN
M	
management client	An NEC EXPRESSCLUSTER Manager-installed client computer.
mirror disk system	A cluster system not utilizing shared disks. Performs mirroring local disks between the servers.
N	
Network Partition syndrome	Interruptions of the heartbeats that are carried out via interconnect, because of LAN failures. (Related term) interconnect, Heartbeats
P	

Term	Description
private LAN	Same meaning as interconnect-dedicated LAN. (Related term) interconnect, Public LAN
primary (Server)	A server specified as the main server in a certain failover group. (Related term) Secondary (Server)
physical IP address	Opposition of virtual IP address. Assigned to each machine for its communication. (Related term) virtual IP address
PP (Program Product)	A commercially available software product.
public LAN	A communication path used between servers and clients (Related term) interconnect, private LAN
R	
recovery of a cluster	To return a failed and isolated server back to the cluster, after the server was restored.
S	
secondary (server)	The server to which a fileover group will fail over; from a viewpoint of normal operation. (Related term) primary server
shared disk	A disk to which more than one server can access simultaneously. (Related term) cross call disk
shared disk system	A cluster system utilizing a shared disk.
shared partition	A disk partition connected with more than one computer and can be accessed by them simultaneously. (Related term) switched partition, CLUSTER partition
shutdown cluster	Shutting down all servers in a cluster system by using NEC EXPRESSCLUSTER Manager. This is regarded as a normal operation.
Split-brain-syndrome	-> Network Partition
standby system	A server that is not the active server. (Related term) active system.
startup attribute	An attribute of a failover group, decides start a failover group automatically or manually in startup of a cluster system. You can specify this from management client.
switched partition	A disk partition connected to more than one computer and can be switched according to its use. (Related term) shared partition, CLUSTER partition
switched mirror disk	A set of disks that can be used as if it were only one disk, due to their disk mirroring. (Related term) CLUSTER partition
V	
virtual IP address	Virtual IP addresses that NEC EXPRESSCLUSTER uses. With these IP addresses, applications in clients do not have to be aware of switching of servers during a failover. (Related term) physical IP address
virtual computer name	Virtual Computer names that NEC EXPRESSCLUSTER uses. With these names, applications in clients do not have to be aware switching of servers during a failover.