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Murotani et al.

(54) FILE-SHARING SYSTEM AND METHOD OF USING FILE-SHARING SYSTEM TO GENERATE SINGLE LOGICAL DIRECTORY STRUCTURE

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
G06F 17/30 (2006.01)

(52) **U.S. Cl.** **707/200**; 707/E17.001

(57) **ABSTRACT**

The file sharing system of the present invention is able to provide a client with a single logical directory and reproduces the single logical directory in a remote site when the local site has stopped in use of a remote copy that is made between the local site and remote site. The first site provides the client with a logical directory that is constituted across respective nodes in the first site. The remote copy is executed between the first and second sites, and the data of both sites are synchronized. For the generation of the logical directory and the management of the remote copy, a common management table is used, and the management table is held by all of the nodes. In cases where the first site stops due to a fault, the second site utilizes information related to the remote copy in the management table to construct the logical directory and reproduces the logical directory in the second site.

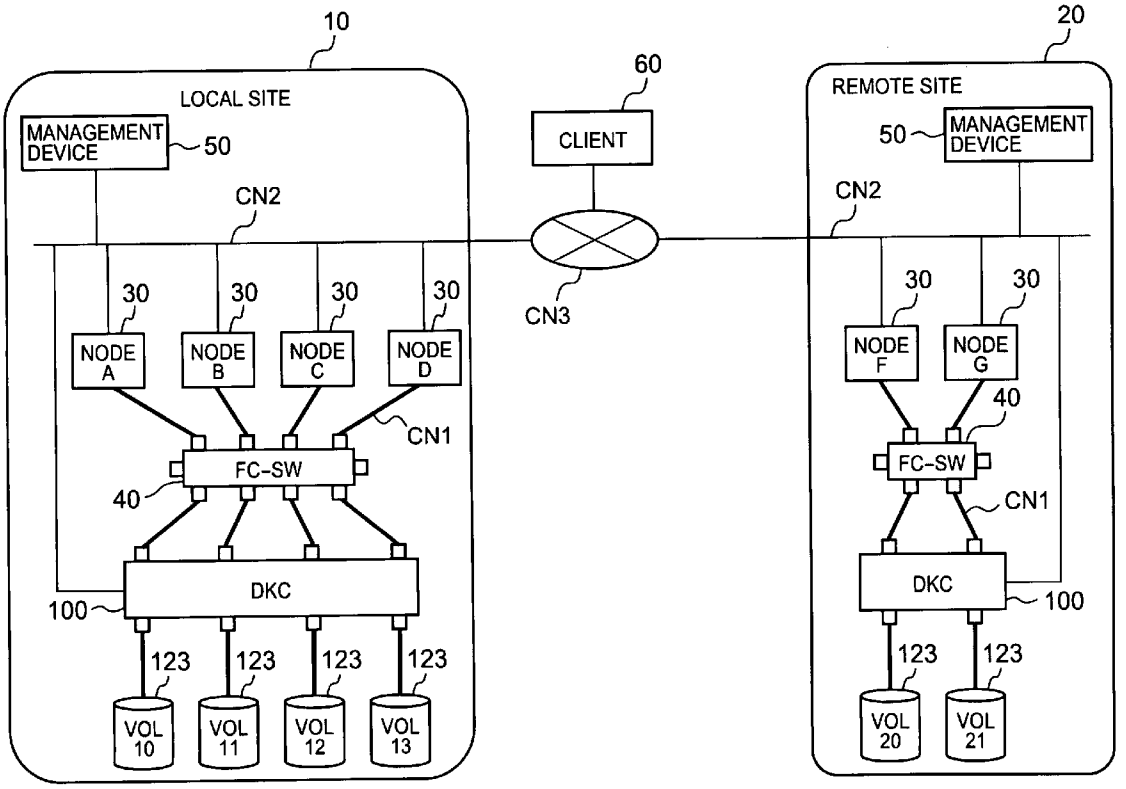


FIG. 1A

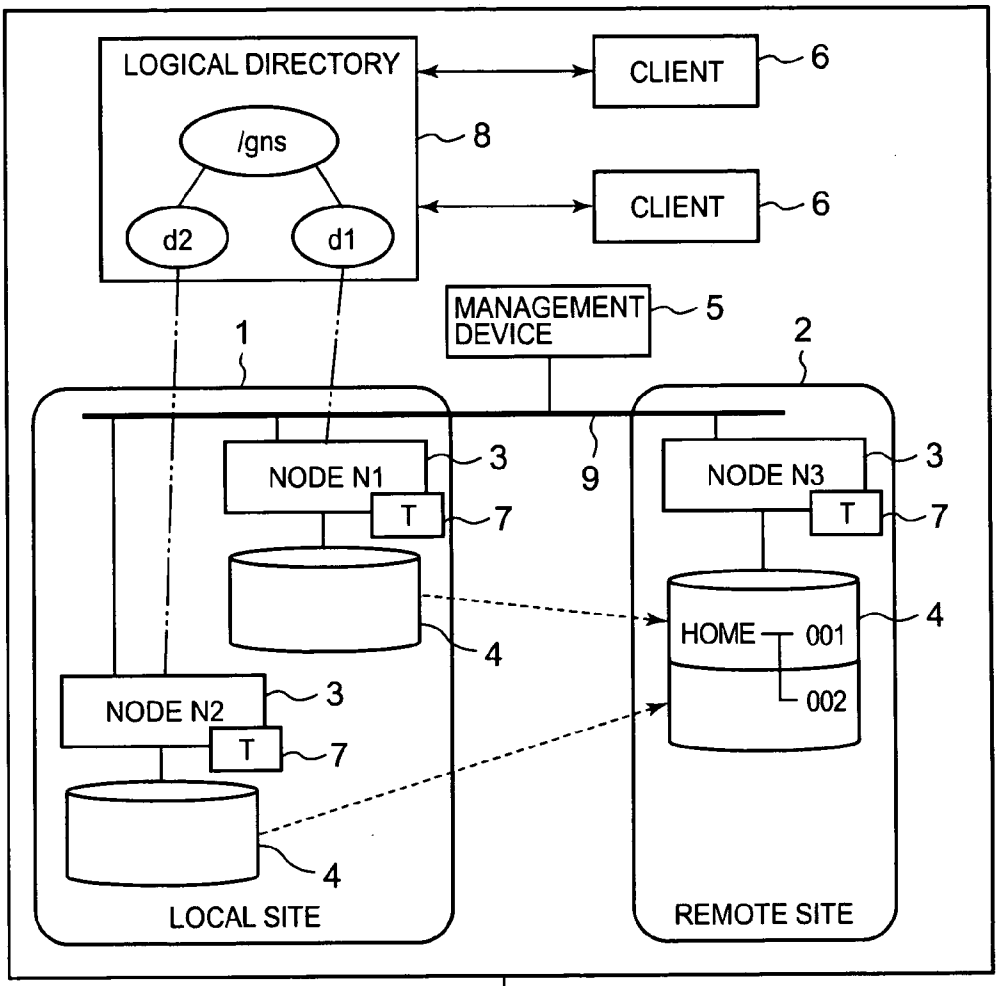

LOGICAL DIRECTORY
/gns
d2
d1
8
CLIENT
6
CLIENT
6
MANAGEMENT DEVICE
5
1
2
9
NODE N1
3
T
7
4
NODE N2
3
T
7
4
NODE N3
3
T
7
HOME
001
002
4
LOCAL SITE
REMOTE SITE

FIG. 1B

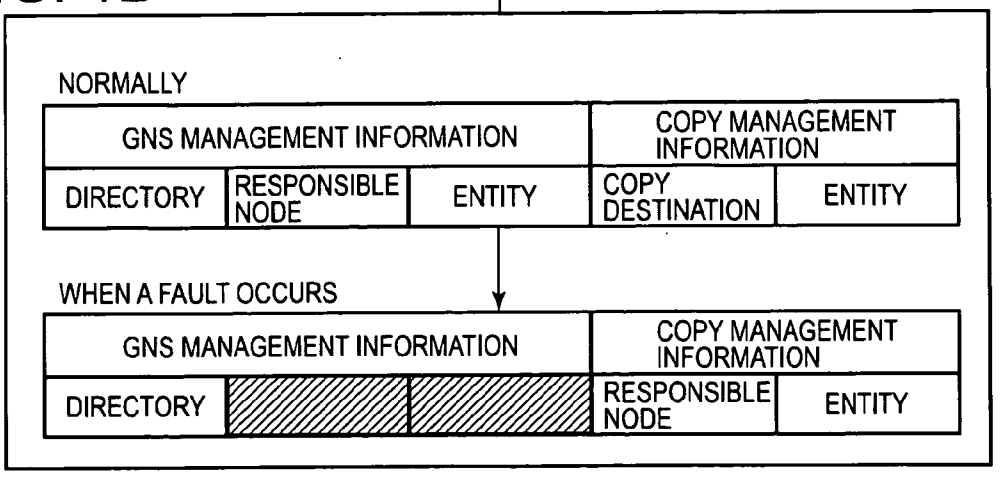

NORMALLY
GNS MANAGEMENT INFORMATION
COPY MANAGEMENT INFORMATION
DIRECTORY
RESPONSIBLE NODE
ENTITY
COPY DESTINATION
ENTITY
WHEN A FAULT OCCURS
GNS MANAGEMENT INFORMATION
COPY MANAGEMENT INFORMATION
DIRECTORY
RESPONSIBLE NODE
ENTITY

FIG. 2

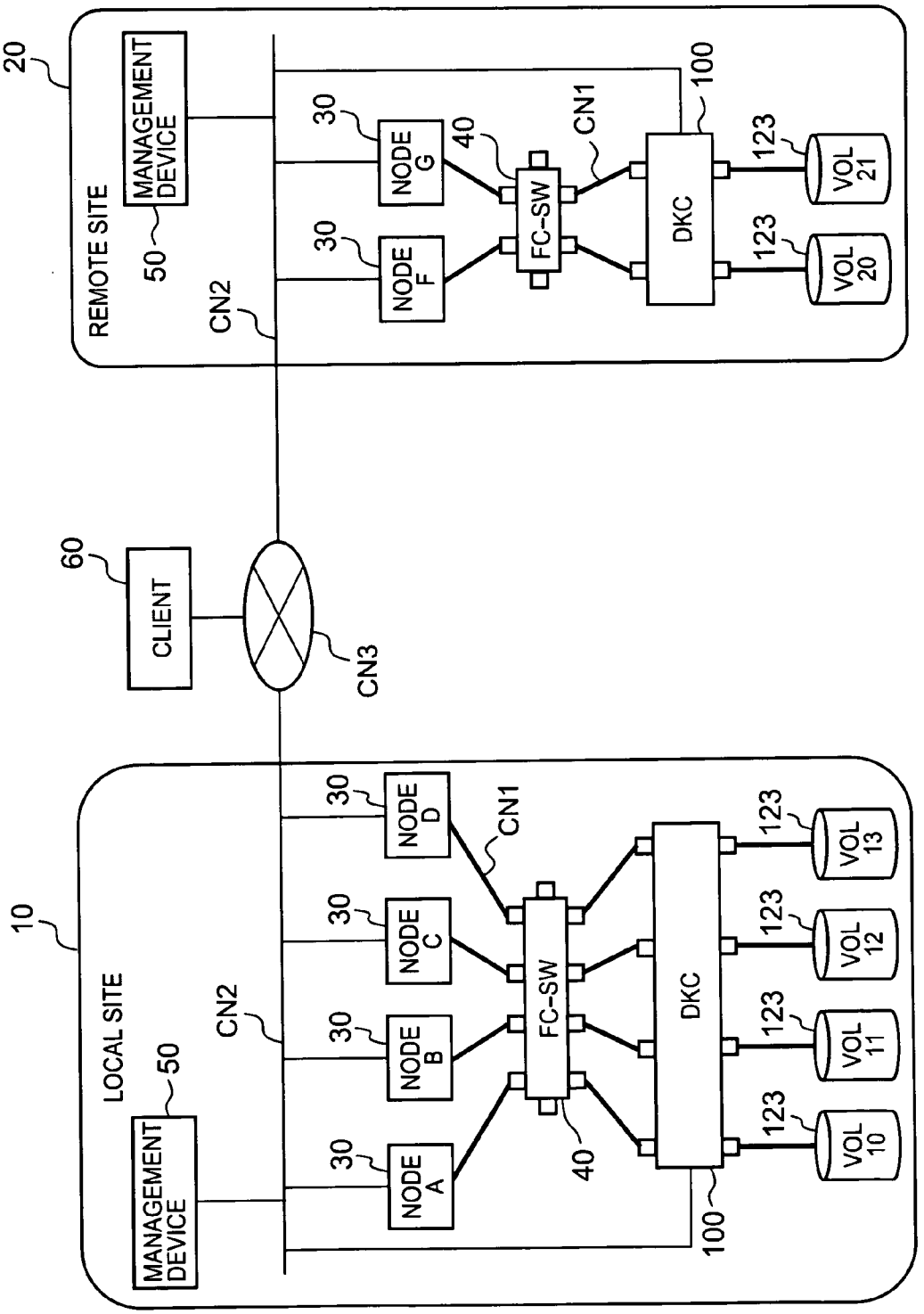

20
REMOTE SITE
MANAGEMENT DEVICE
50
CN2
30
NODE G
30
NODE F
40
FC-SW
CN1
100
DKC
123
VOL 21
123
VOL 20
60
CLIENT
CN3
10
LOCAL SITE
50
MANAGEMENT DEVICE
CN2
30
NODE A
30
NODE B
30
NODE C
30
NODE D
CN1
40
FC-SW
DKC
100
123
VOL 10
123
VOL 11
123
VOL 12
123
VOL 13

FIG. 3

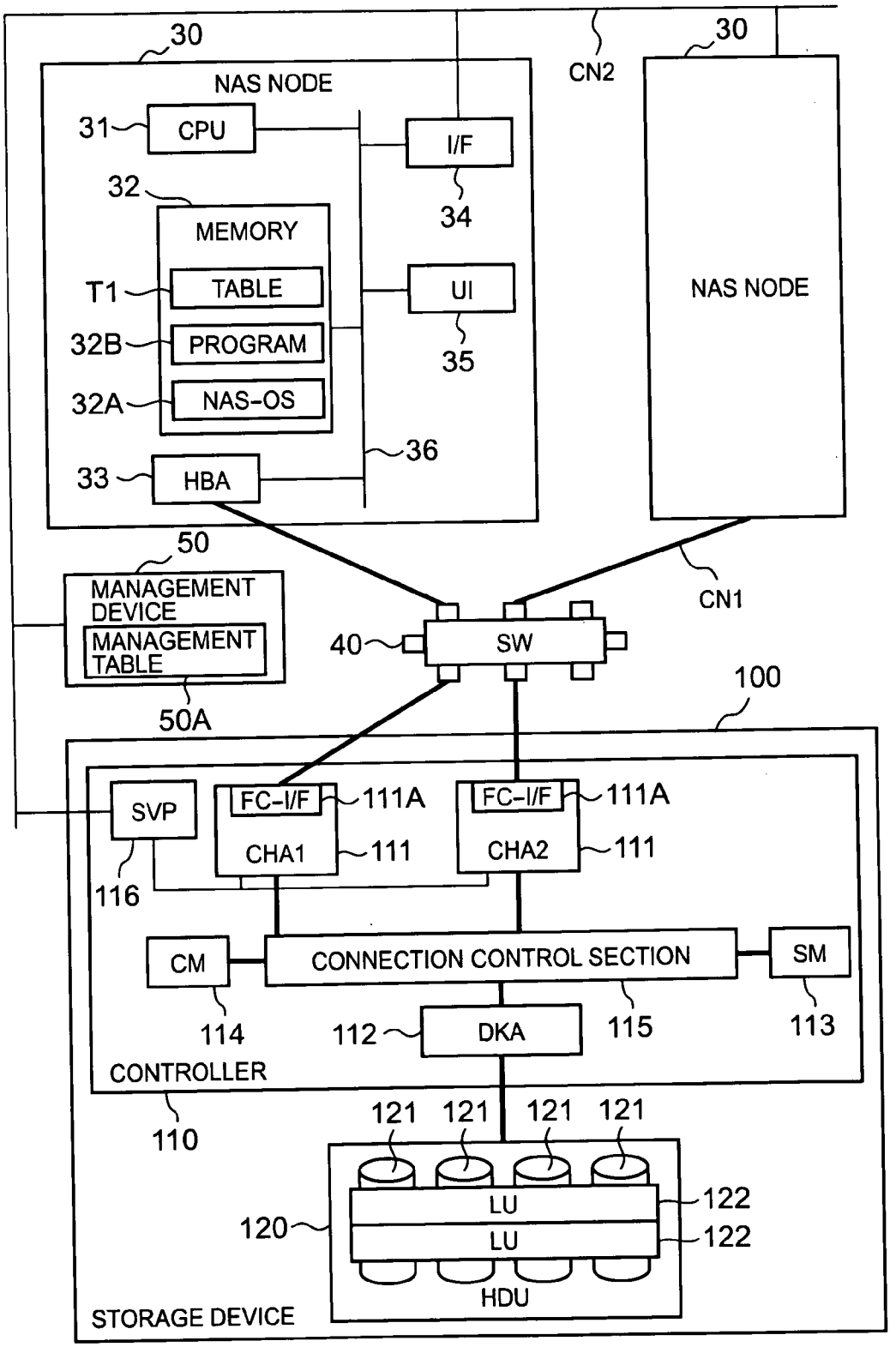

30
NAS NODE
31
CPU
I/F
34
32
MEMORY
T1
TABLE
UI
35
32B
PROGRAM
32A
NAS-OS
36
33
HBA
CN2
30
NAS NODE
50
MANAGEMENT DEVICE
MANAGEMENT TABLE
50A
40
SW
CN1
100
SVP
FC-I/F
111A
CHA1
111
FC-I/F
111A
CHA2
111
116
CM
CONNECTION CONTROL SECTION
SM
114
112
DKA
115
113
CONTROLLER
110
121
121
121
121
120
LU
LU
122
122
HDU
STORAGE DEVICE

FIG. 4A

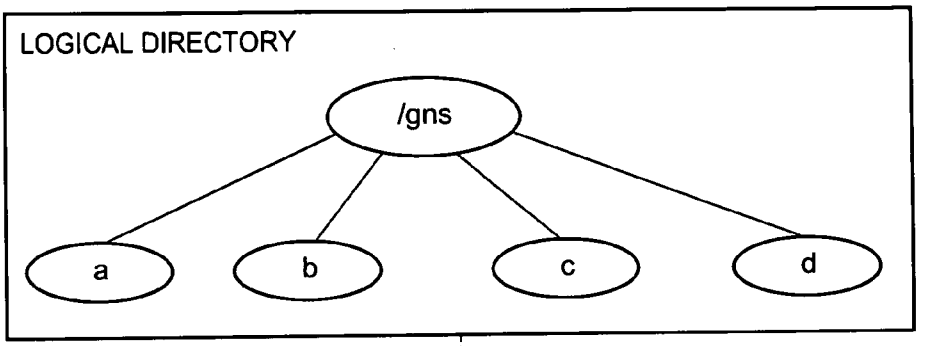


FIG. 4B

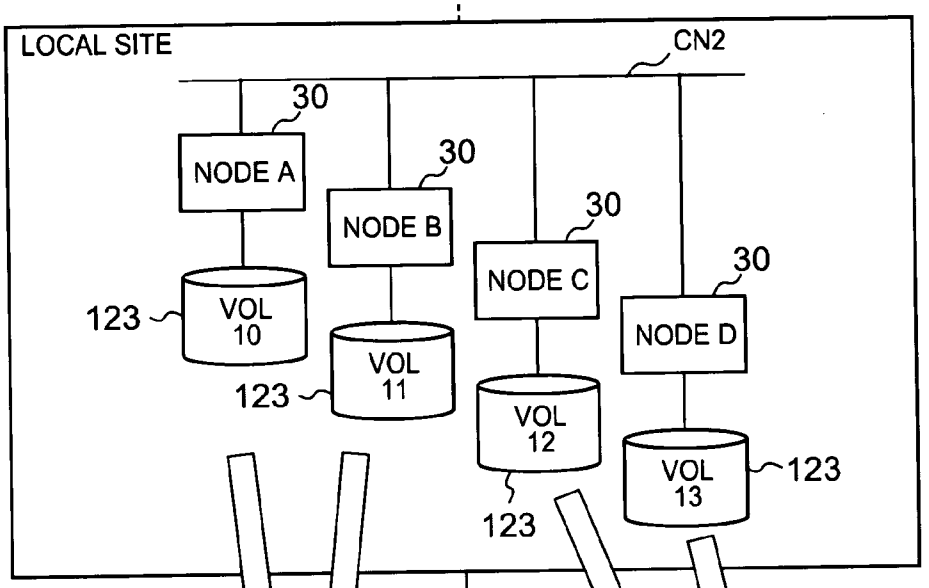


FIG. 4C

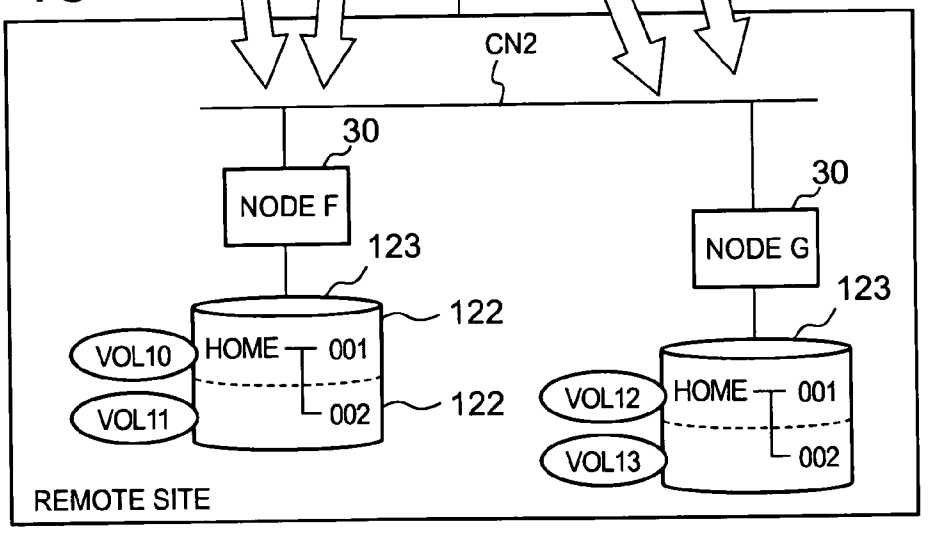


FIG. 5

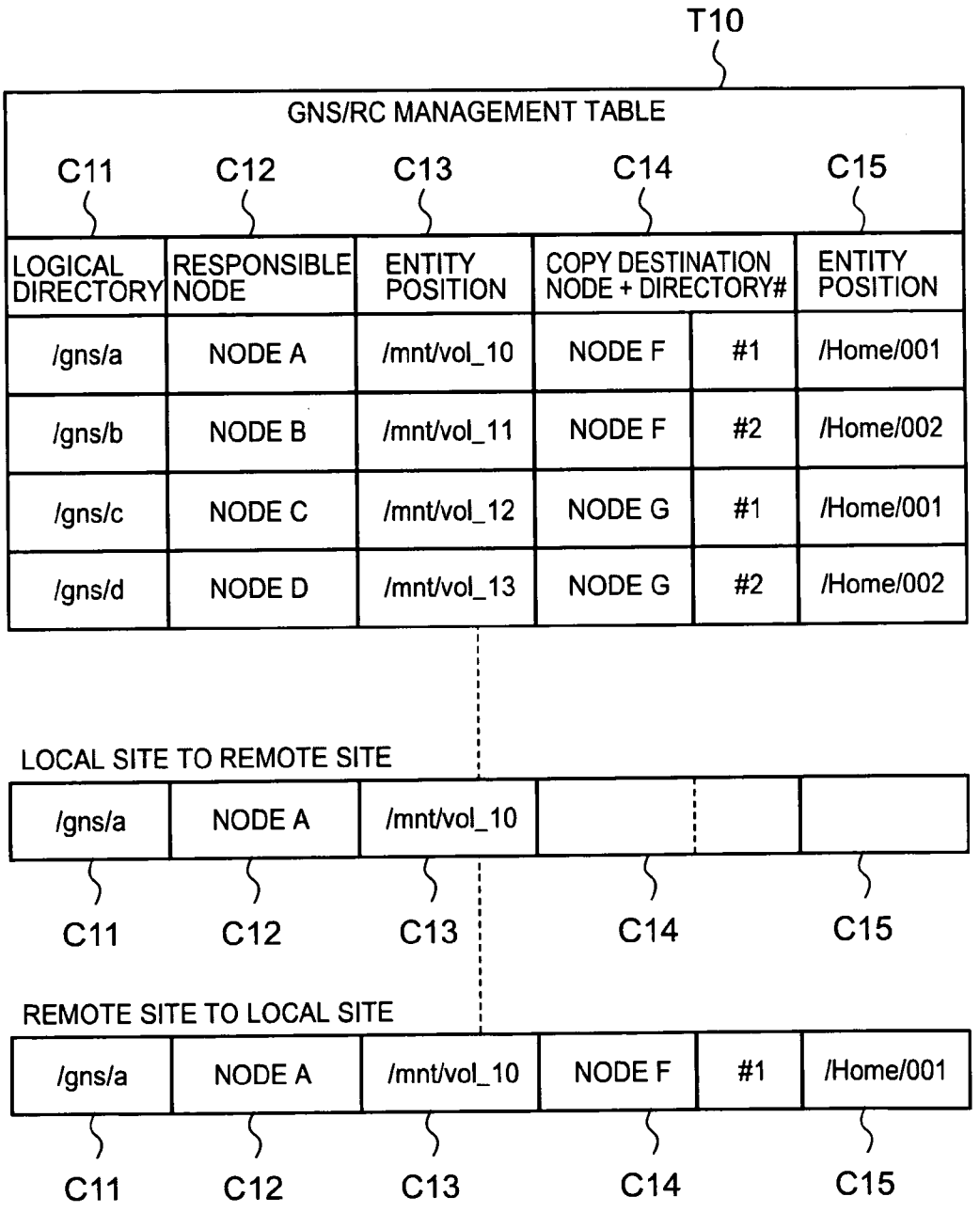

T10
GNS/RC MANAGEMENT TABLE
C11
C12
C13
C14
C15
LOGICAL DIRECTORY
RESPONSIBLE NODE
ENTITY POSITION
COPY DESTINATION NODE + DIRECTORY#
ENTITY POSITION
/gns/a
NODE A
/mnt/vol_10
NODE F
#1
/Home/001
/gns/b
NODE B
/mnt/vol_11
NODE F
#2
/Home/002
/gns/c
NODE C
/mnt/vol_12
NODE G
#1
/Home/001
/gns/d
NODE D
/mnt/vol_13
NODE G
#2
/Home/002
LOCAL SITE TO REMOTE SITE
/gns/a
NODE A
/mnt/vol_10
C11
C12
C13
C14
C15
REMOTE SITE TO LOCAL SITE
/gns/a
NODE A
/mnt/vol_10
NODE F
#1
/Home/001
C11
C12
C13
C14
C15

FIG. 6

T10

GNS/RC MANAGEMENT TABLE

C11	C12	C13	C14		C15
LOGICAL DIRECTORY	RESPONSIBLE NODE	ENTITY POSITION	COPY DESTINATION NODE + DIRECTORY #		ENTITY POSITION
/gns/a	NODE A	/mnt/vol_10	NODE F	#1	/Home/001
/gns/b	NODE B	/mnt/vol_11	NODE F	#2	/Home/002
/gns/c	NODE C	/mnt/vol_12	NODE G	#1	/Home/001
/gns/d	NODE D	/mnt/vol_13	NODE G	#2	/Home/002

T10

GNS/RC MANAGEMENT TABLE

C11		C14		C15
LOGICAL DIRECTORY		RESPONSIBLE NODE		ENTITY POSITION
/gns/a		NODE F	#1	/Home/001
/gns/b		NODE F	#2	/Home/002
/gns/c		NODE G	#1	/Home/001
/gns/d		NODE G	#2	/Home/002

FIG. 7

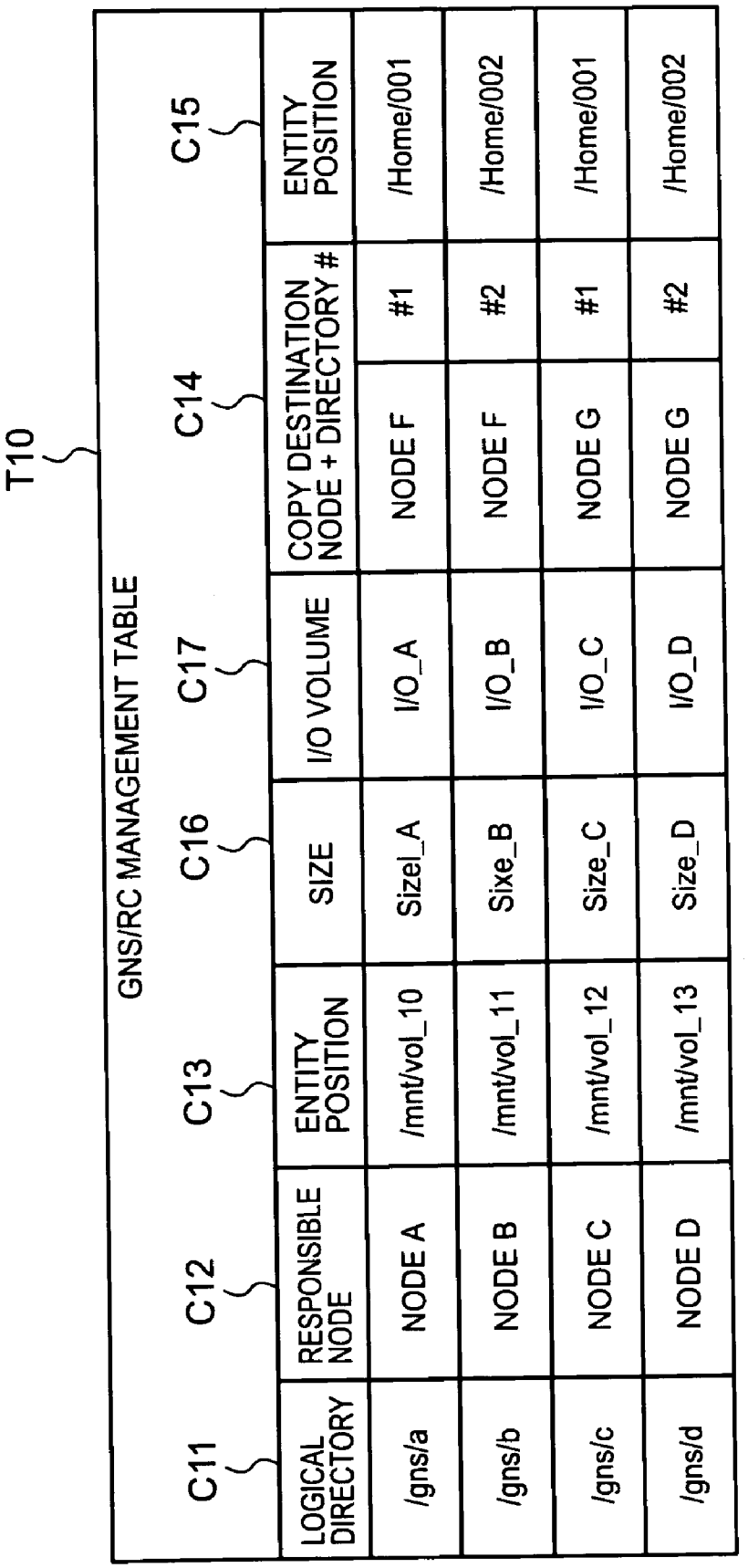

T10
GNS/RC MANAGEMENT TABLE
C11
C12
C13
C16
C17
C14
C15
LOGICAL DIRECTORY
RESPONSIBLE NODE
ENTITY POSITION
SIZE
I/O VOLUME
COPY DESTINATION NODE + DIRECTORY #
ENTITY POSITION
/gns/a
NODE A
/mnt/vol_10
Sizel_A
I/O_A
NODE F
#1
/Home/001
/gns/b
NODE B
/mnt/vol_11
Sixe_B
I/O_B
NODE F
#2
/Home/002
/gns/c
NODE C
/mnt/vol_12
Size_C
I/O_C
NODE G
#1
/Home/001
/gns/d
NODE D
/mnt/vol_13
Size_D
I/O_D
NODE G
#2
/Home/002

FIG. 8

T20

SYSTEM CONSTITUTION MANAGEMENT TABLE

C21	C22	C23	C24	C25	C26
SITE NAME	NODE NAME	IP ADDRESS	MASTER RANKING	SUBMASTER RANKING	OTHER
LOCAL SITE	NODE A	IP_A	1	–	
	NODE B	IP_B	2	–	
	NODE C	IP_C	–	–	
	NODE D	IP_D	–	–	
REMOTE SITE	NODE F	IP_F	–	1	
	NODE G	IP_G	–	2	

FIG. 9

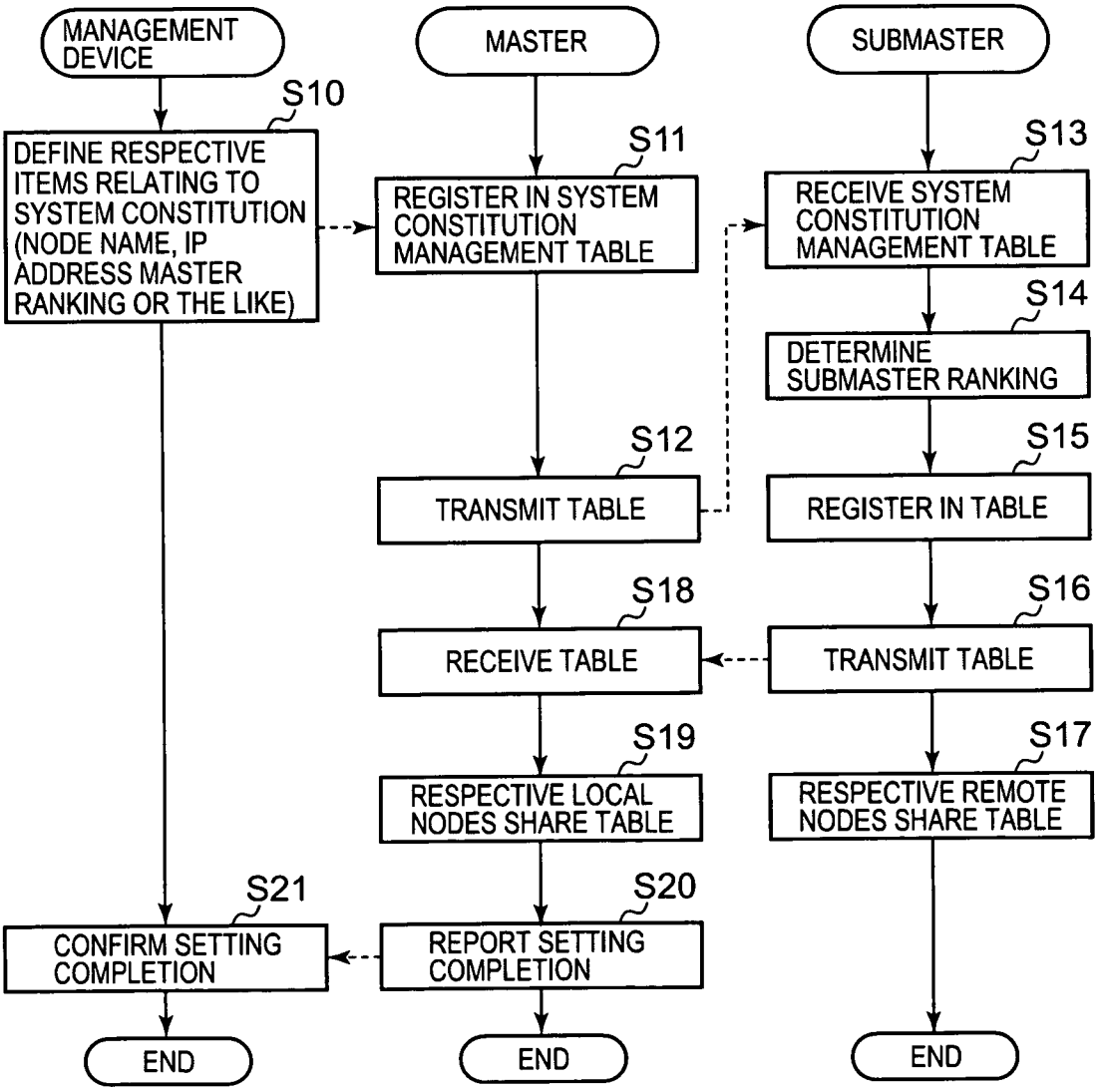

MANAGEMENT DEVICE
MASTER
SUBMASTER
S10
DEFINE RESPECTIVE ITEMS RELATING TO SYSTEM CONSTITUTION (NODE NAME, IP ADDRESS MASTER RANKING OR THE LIKE)
S11
REGISTER IN SYSTEM CONSTITUTION MANAGEMENT TABLE
S13
RECEIVE SYSTEM CONSTITUTION MANAGEMENT TABLE
S14
DETERMINE SUBMASTER RANKING
S12
TRANSMIT TABLE
S15
REGISTER IN TABLE
S18
RECEIVE TABLE
S16
TRANSMIT TABLE
S19
RESPECTIVE LOCAL NODES SHARE TABLE
S17
RESPECTIVE REMOTE NODES SHARE TABLE
S21
CONFIRM SETTING COMPLETION
S20
REPORT SETTING COMPLETION
END
END
END

FIG. 10

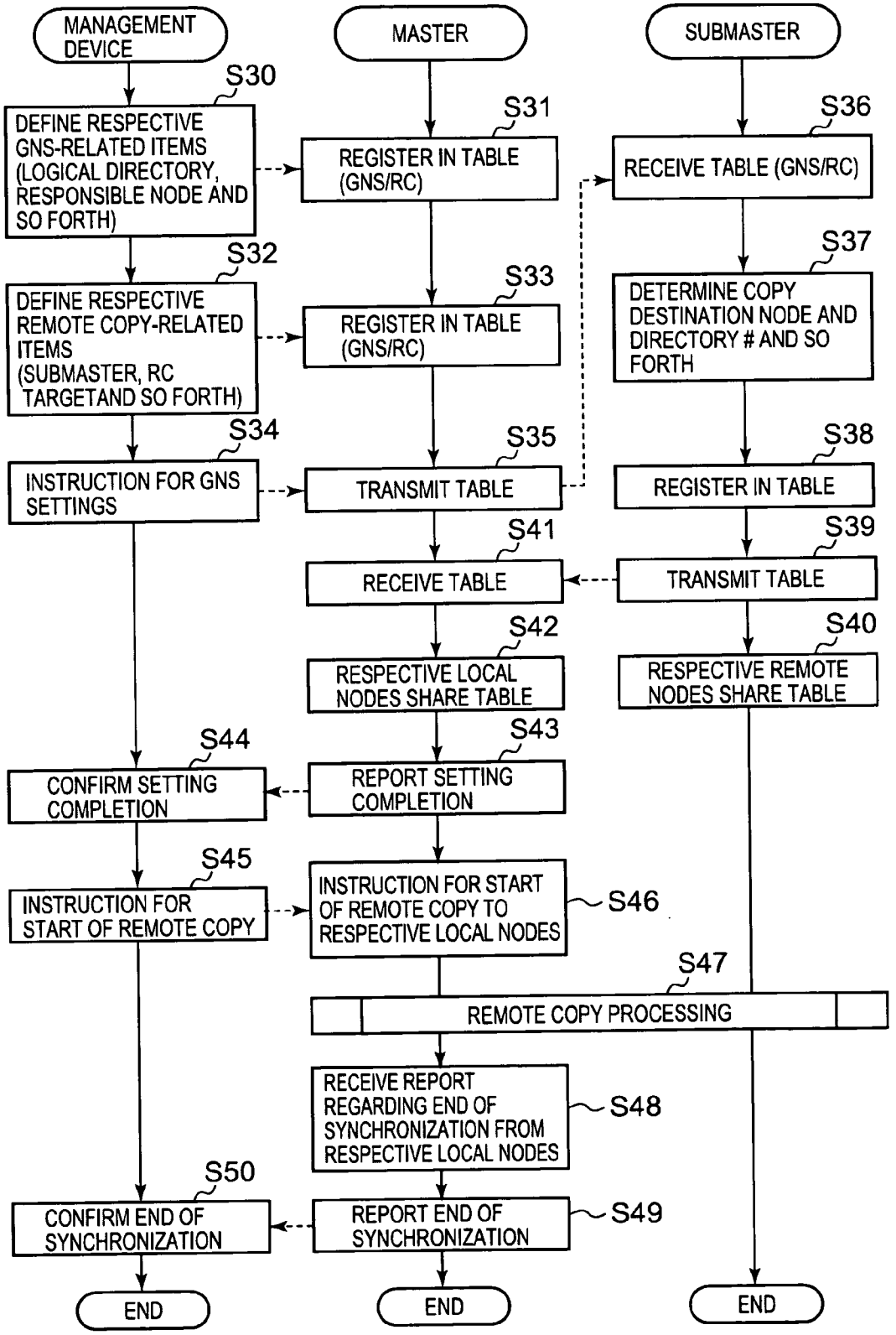

MANAGEMENT DEVICE
MASTER
SUBMASTER
S30
DEFINE RESPECTIVE GNS-RELATED ITEMS (LOGICAL DIRECTORY, RESPONSIBLE NODE AND SO FORTH)
S31
REGISTER IN TABLE (GNS/RC)
S36
RECEIVE TABLE (GNS/RC)
S32
DEFINE RESPECTIVE REMOTE COPY-RELATED ITEMS (SUBMASTER, RC TARGETAND SO FORTH)
S33
REGISTER IN TABLE (GNS/RC)
S37
DETERMINE COPY DESTINATION NODE AND DIRECTORY # AND SO FORTH
S34
INSTRUCTION FOR GNS SETTINGS
S35
TRANSMIT TABLE
S38
REGISTER IN TABLE
S41
RECEIVE TABLE
S39
TRANSMIT TABLE
S42
RESPECTIVE LOCAL NODES SHARE TABLE
S40
RESPECTIVE REMOTE NODES SHARE TABLE
S44
CONFIRM SETTING COMPLETION
S43
REPORT SETTING COMPLETION
S45
INSTRUCTION FOR START OF REMOTE COPY
INSTRUCTION FOR START OF REMOTE COPY TO RESPECTIVE LOCAL NODES
S46
S47
REMOTE COPY PROCESSING
RECEIVE REPORT REGARDING END OF SYNCHRONIZATION FROM RESPECTIVE LOCAL NODES
S48
S50
CONFIRM END OF SYNCHRONIZATION
REPORT END OF SYNCHRONIZATION
S49
END
END
END

FIG. 11

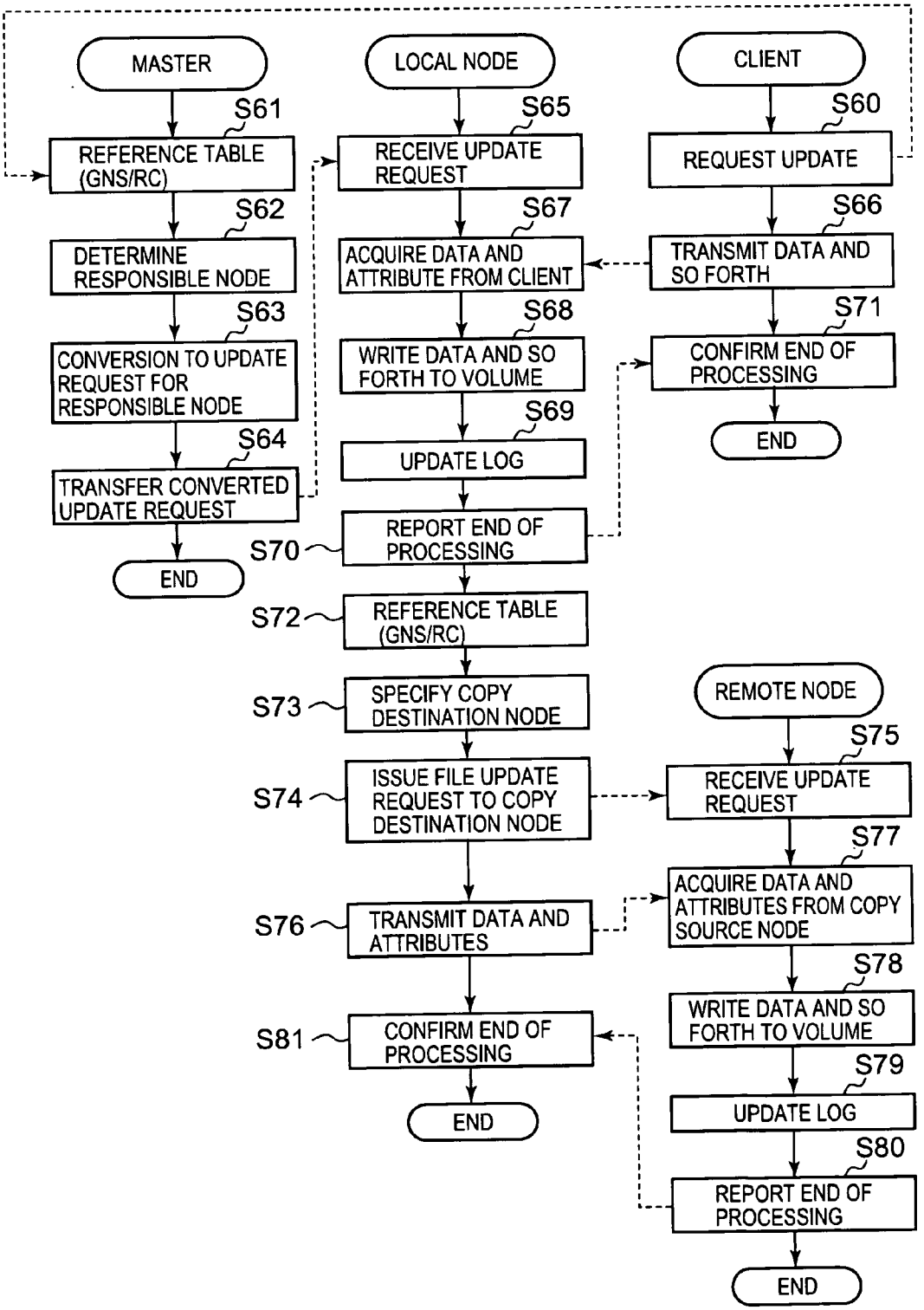
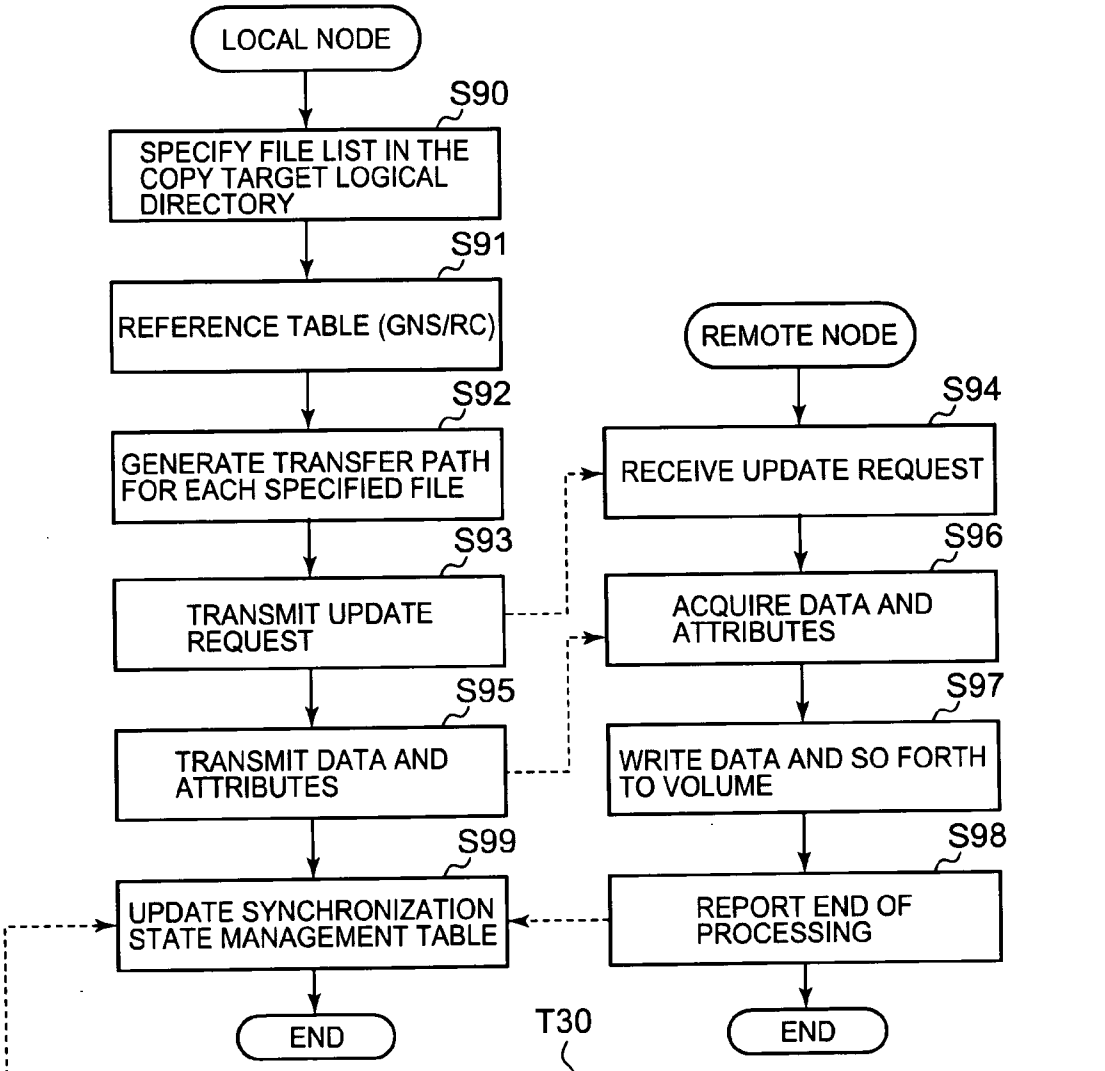

MASTER
S61
REFERENCE TABLE (GNS/RC)
S62
DETERMINE RESPONSIBLE NODE
S63
CONVERSION TO UPDATE REQUEST FOR RESPONSIBLE NODE
S64
TRANSFER CONVERTED UPDATE REQUEST
END
LOCAL NODE
S65
RECEIVE UPDATE REQUEST
S67
ACQUIRE DATA AND ATTRIBUTE FROM CLIENT
S68
WRITE DATA AND SO FORTH TO VOLUME
S69
UPDATE LOG
S70
REPORT END OF PROCESSING
S72
REFERENCE TABLE (GNS/RC)
S73
SPECIFY COPY DESTINATION NODE
S74
ISSUE FILE UPDATE REQUEST TO COPY DESTINATION NODE
S76
TRANSMIT DATA AND ATTRIBUTES
S81
CONFIRM END OF PROCESSING
END
CLIENT
S60
REQUEST UPDATE
S66
TRANSMIT DATA AND SO FORTH
S71
CONFIRM END OF PROCESSING
END
REMOTE NODE
S75
RECEIVE UPDATE REQUEST
S77
ACQUIRE DATA AND ATTRIBUTES FROM COPY SOURCE NODE
S78
WRITE DATA AND SO FORTH TO VOLUME
S79
UPDATE LOG
S80
REPORT END OF PROCESSING
END

FIG. 12



T30

SYNCHRONIZATION STATE MANAGEMENT TABLE

C31 LOGICAL DIRECTORY	C32 VOLUME	C33 FILE	C34 TRANSFER PATH	C35 SYNCHRONIZATION FLAG
/gns/a	/mnt/vol_10	/dir1/file1.txt	/mnt/vol_10/dir1/file1.txt	COMPLETE
		/dir1/file2.jpg	/mnt/vol_10/dir1/file2.jpg	COMPLETE
		/dir1/file3.jpg	/mnt/vol_10/dir1/file3.jpg	-

FIG. 13

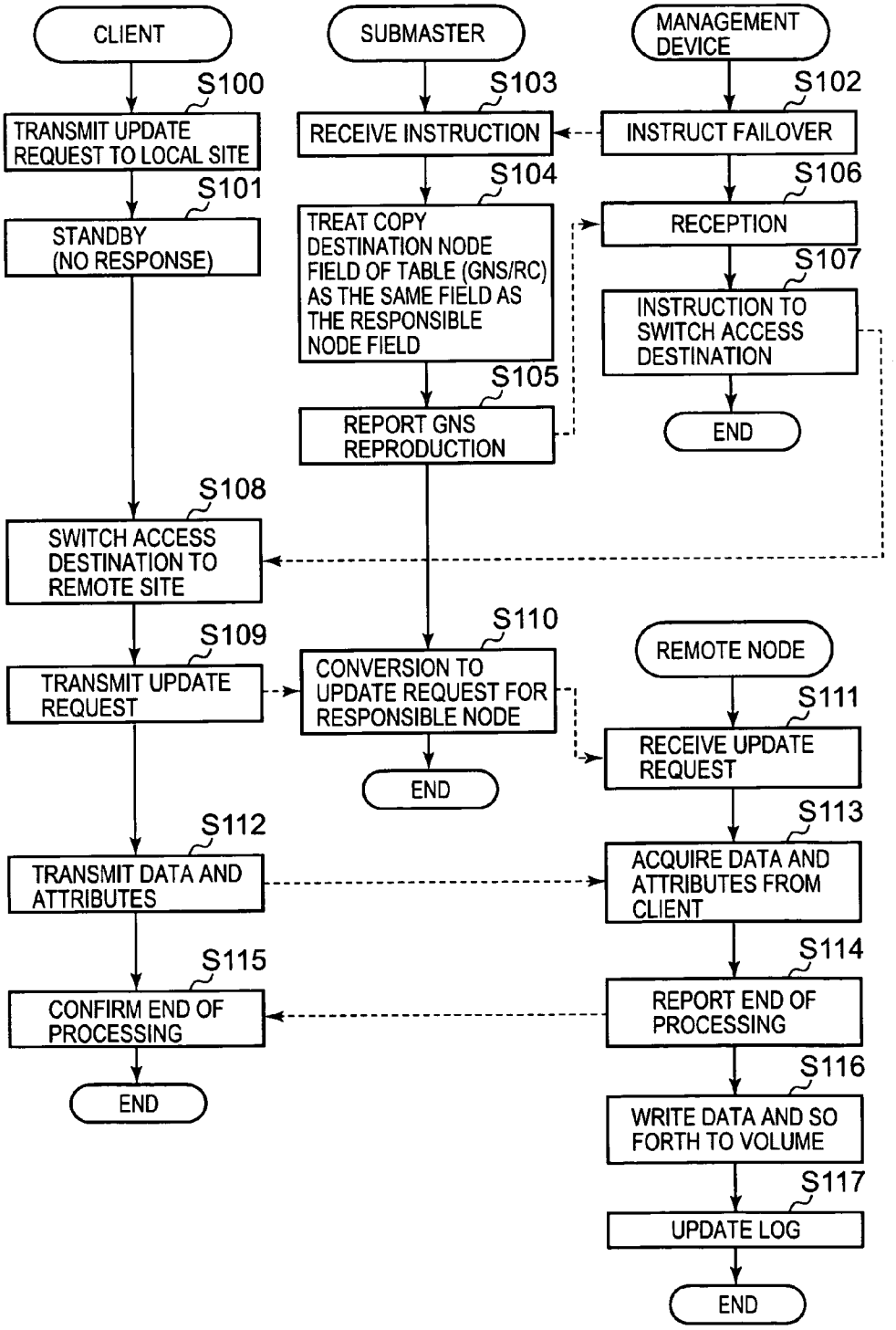

CLIENT
SUBMASTER
MANAGEMENT DEVICE
S100
TRANSMIT UPDATE REQUEST TO LOCAL SITE
S101
STANDBY (NO RESPONSE)
S103
RECEIVE INSTRUCTION
S104
TREAT COPY DESTINATION NODE FIELD OF TABLE (GNS/RC) AS THE SAME FIELD AS THE RESPONSIBLE NODE FIELD
S105
REPORT GNS REPRODUCTION
S102
INSTRUCT FAILOVER
S106
RECEPTION
S107
INSTRUCTION TO SWITCH ACCESS DESTINATION
END
S108
SWITCH ACCESS DESTINATION TO REMOTE SITE
S109
TRANSMIT UPDATE REQUEST
S110
CONVERSION TO UPDATE REQUEST FOR RESPONSIBLE NODE
END
REMOTE NODE
S111
RECEIVE UPDATE REQUEST
S112
TRANSMIT DATA AND ATTRIBUTES
S113
ACQUIRE DATA AND ATTRIBUTES FROM CLIENT
S114
REPORT END OF PROCESSING
S115
CONFIRM END OF PROCESSING
END
S116
WRITE DATA AND SO FORTH TO VOLUME
S117
UPDATE LOG
END

FIG. 14

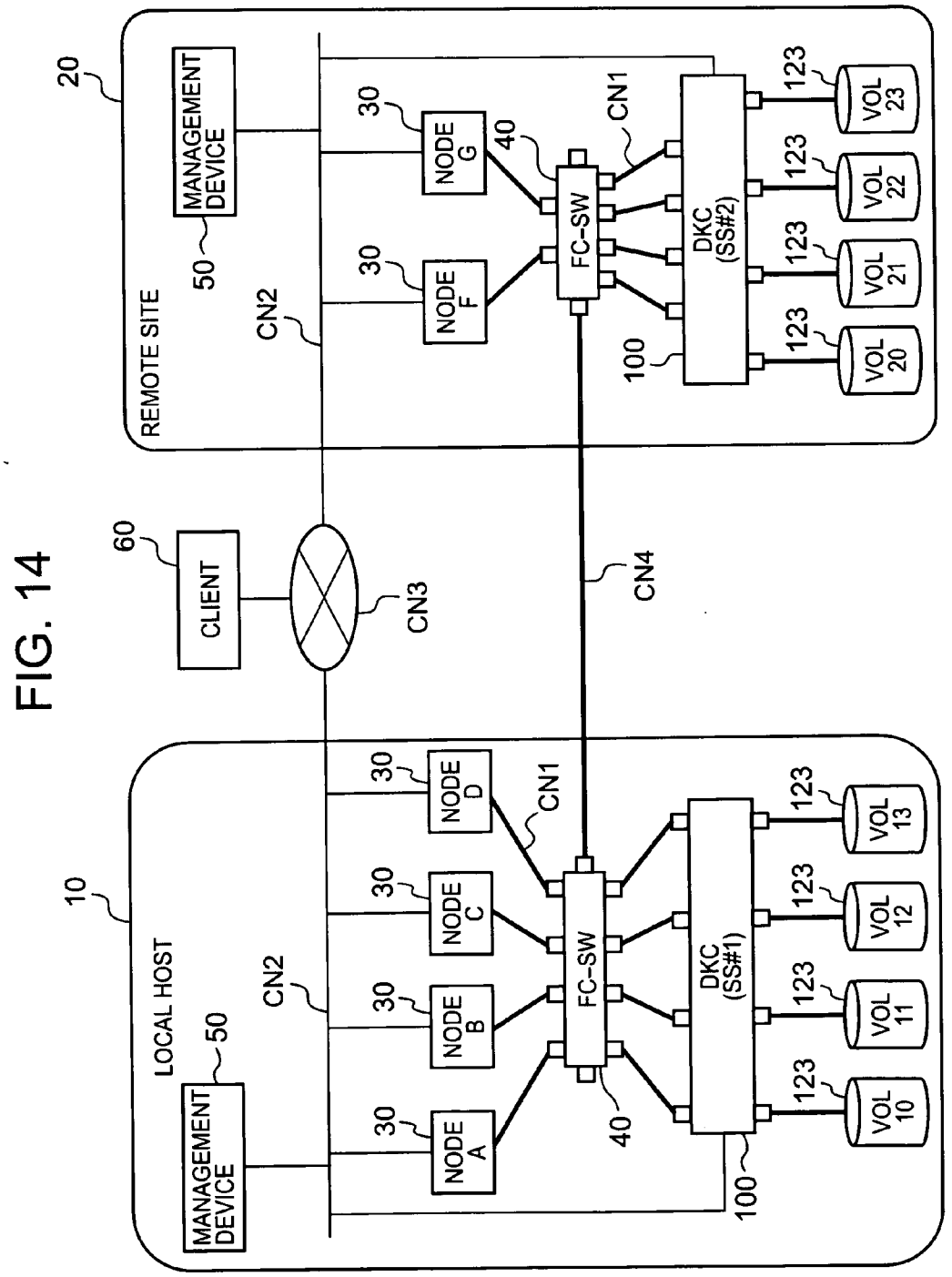

20
REMOTE SITE
MANAGEMENT DEVICE
50
CN2
30
NODE G
NODE F
40
FC-SW
CN1
DKC (SS#2)
100
123
VOL 23
VOL 22
VOL 21
VOL 20
60
CLIENT
CN3
CN4
10
LOCAL HOST
MANAGEMENT DEVICE
50
CN2
30
NODE A
NODE B
NODE C
NODE D
FC-SW
40
CN1
DKC (SS#1)
100
123
VOL 10
VOL 11
VOL 12
VOL 13

FIG. 15

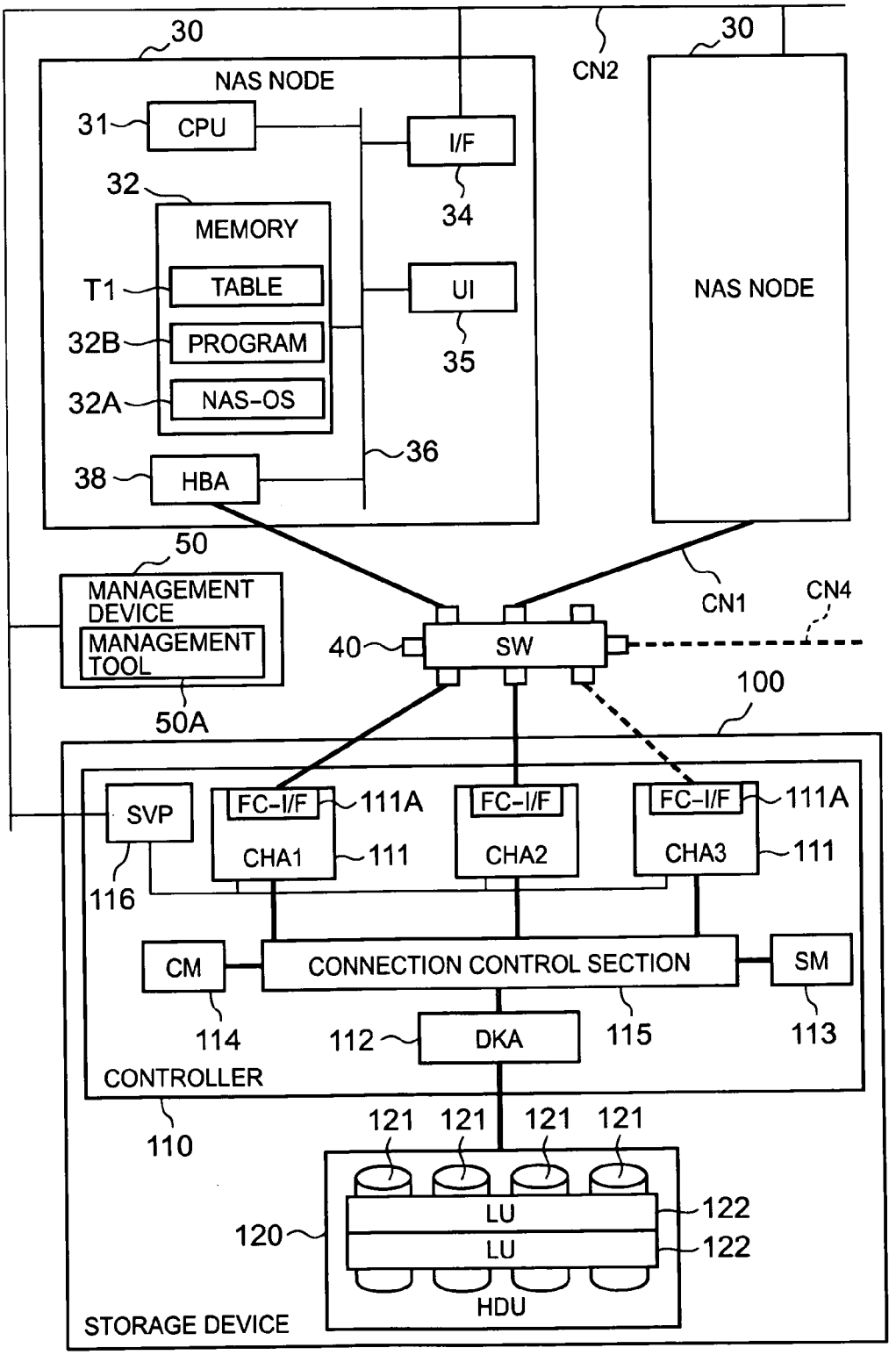

30
NAS NODE
31
CPU
I/F
34
32
MEMORY
T1
TABLE
UI
35
32B
PROGRAM
32A
NAS-OS
36
38
HBA
CN2
30
NAS NODE
50
MANAGEMENT DEVICE
MANAGEMENT TOOL
50A
CN1
CN4
40
SW
100
SVP
116
FC-I/F
111A
CHA1
111
FC-I/F
CHA2
FC-I/F
111A
CHA3
111
CM
CONNECTION CONTROL SECTION
SM
114
112
DKA
115
113
CONTROLLER
110
121
121
121
121
LU
LU
122
122
120
HDU
STORAGE DEVICE

FIG. 16

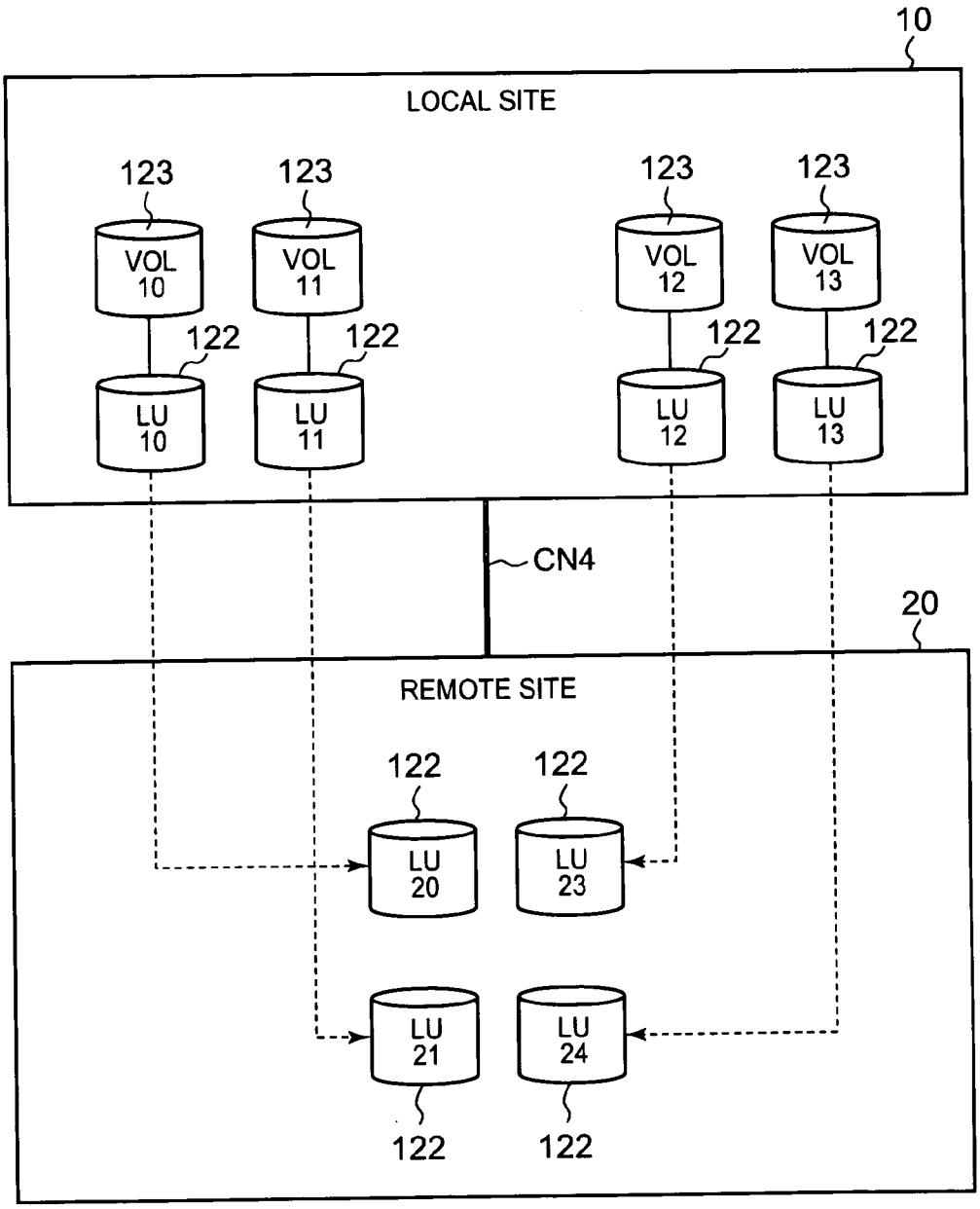

10
LOCAL SITE
123
123
123
123
VOL 10
VOL 11
VOL 12
VOL 13
122
122
122
122
LU 10
LU 11
LU 12
LU 13
CN4
20
REMOTE SITE
122
122
LU 20
LU 23
LU 21
LU 24
122
122

FIG. 17

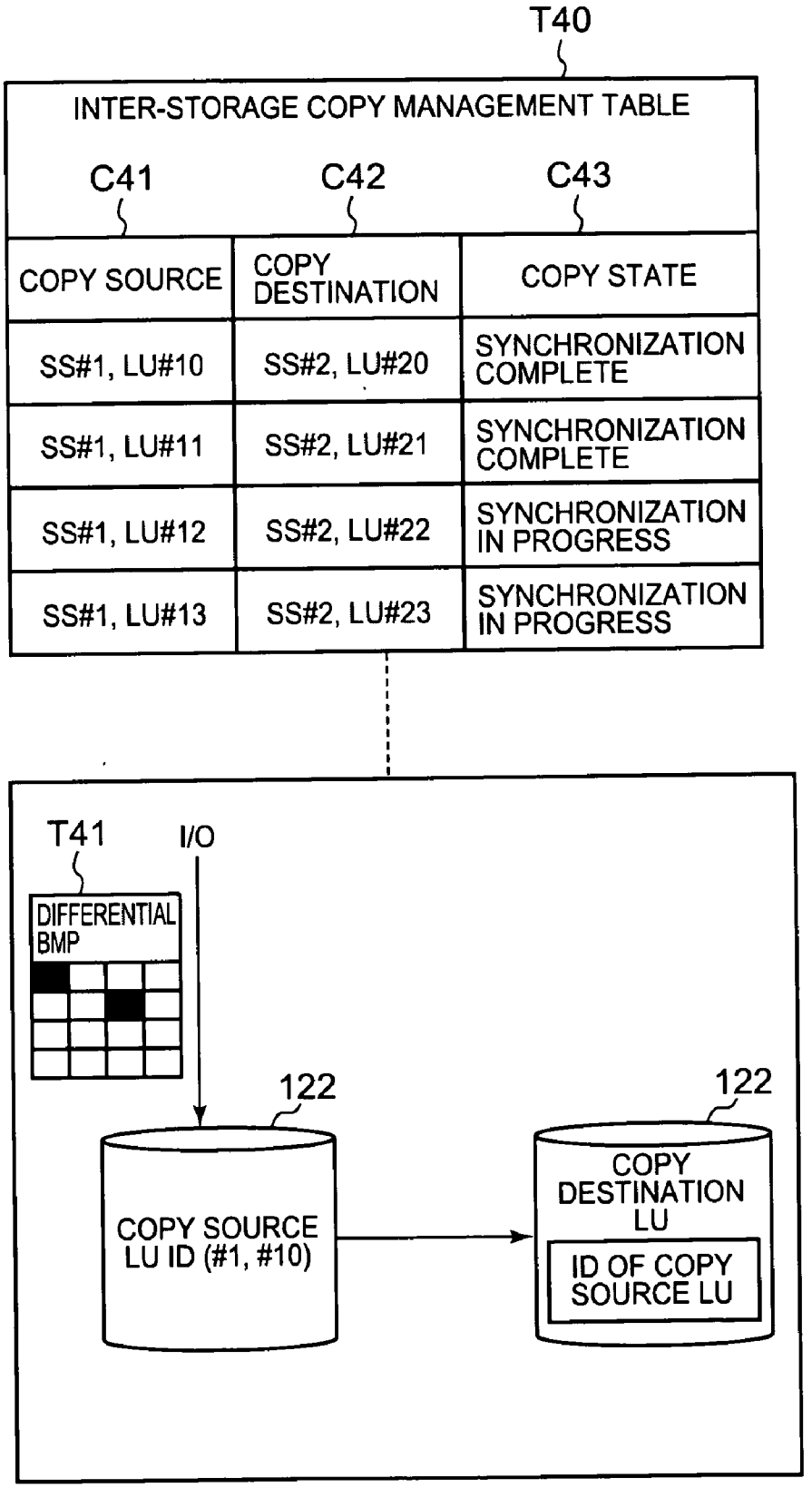

T40
INTER-STORAGE COPY MANAGEMENT TABLE
C41
C42
C43
COPY SOURCE
COPY DESTINATION
COPY STATE
SS#1, LU#10
SS#2, LU#20
SYNCHRONIZATION COMPLETE
SS#1, LU#11
SS#2, LU#21
SYNCHRONIZATION COMPLETE
SS#1, LU#12
SS#2, LU#22
SYNCHRONIZATION IN PROGRESS
SS#1, LU#13
SS#2, LU#23
SYNCHRONIZATION IN PROGRESS
T41
I/O
DIFFERENTIAL BMP
122
122
COPY SOURCE LU ID (#1, #10)
COPY DESTINATION LU
ID OF COPY SOURCE LU

FIG. 18

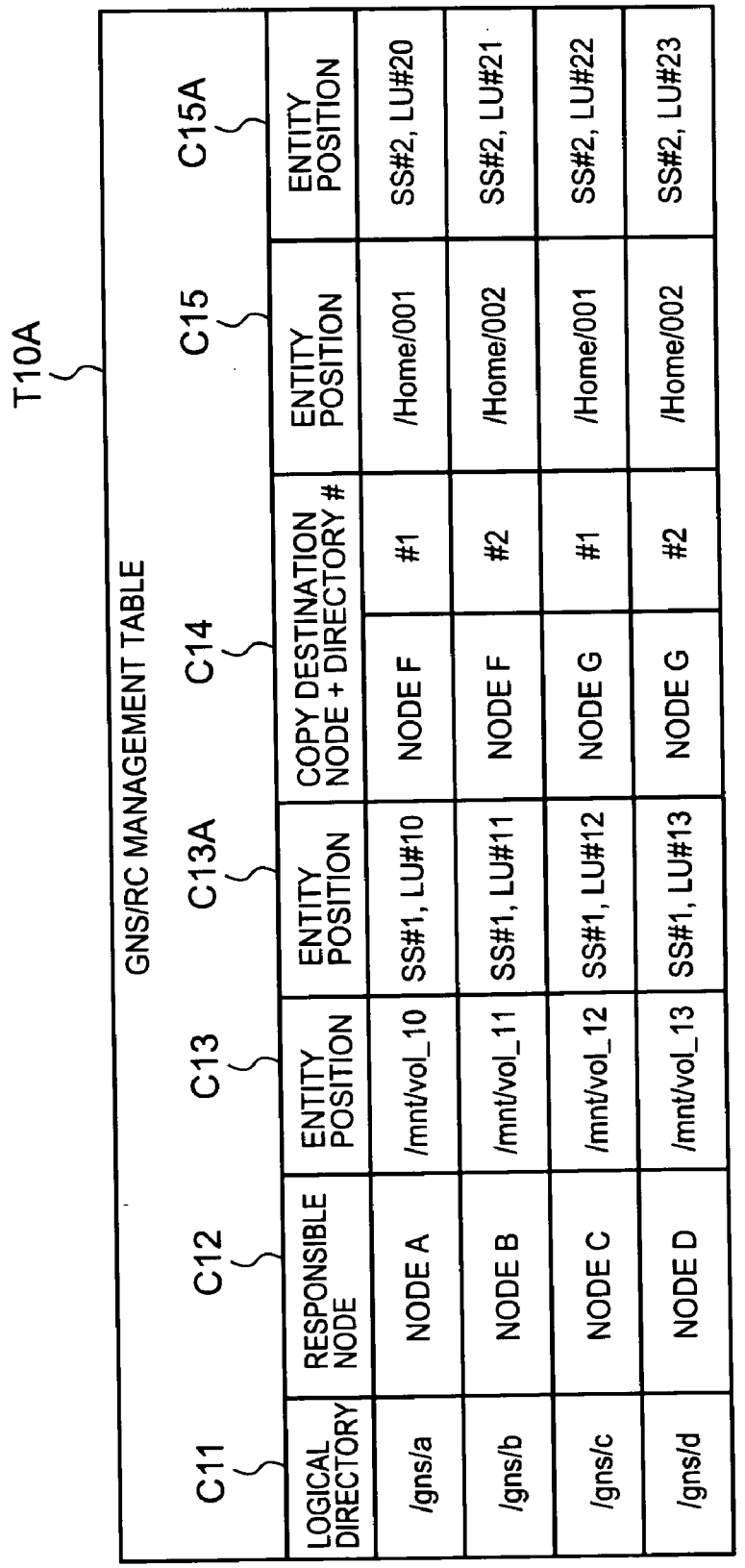

T10A
GNS/RC MANAGEMENT TABLE
C11
C12
C13
C13A
C14
C15
C15A
LOGICAL DIRECTORY
RESPONSIBLE NODE
ENTITY POSITION
ENTITY POSITION
COPY DESTINATION NODE + DIRECTORY #
ENTITY POSITION
/gns/a
NODE A
/mnt/vol_10
SS#1, LU#10
NODE F
#1
/Home/001
SS#2, LU#20
/gns/b
NODE B
/mnt/vol_11
SS#1, LU#11
NODE F
#2
/Home/002
SS#2, LU#21
/gns/c
NODE C
/mnt/vol_12
SS#1, LU#12
NODE G
#1
/Home/001
SS#2, LU#22
/gns/d
NODE D
/mnt/vol_13
SS#1, LU#13
NODE G
#2
/Home/002
SS#2, LU#23

FIG. 19

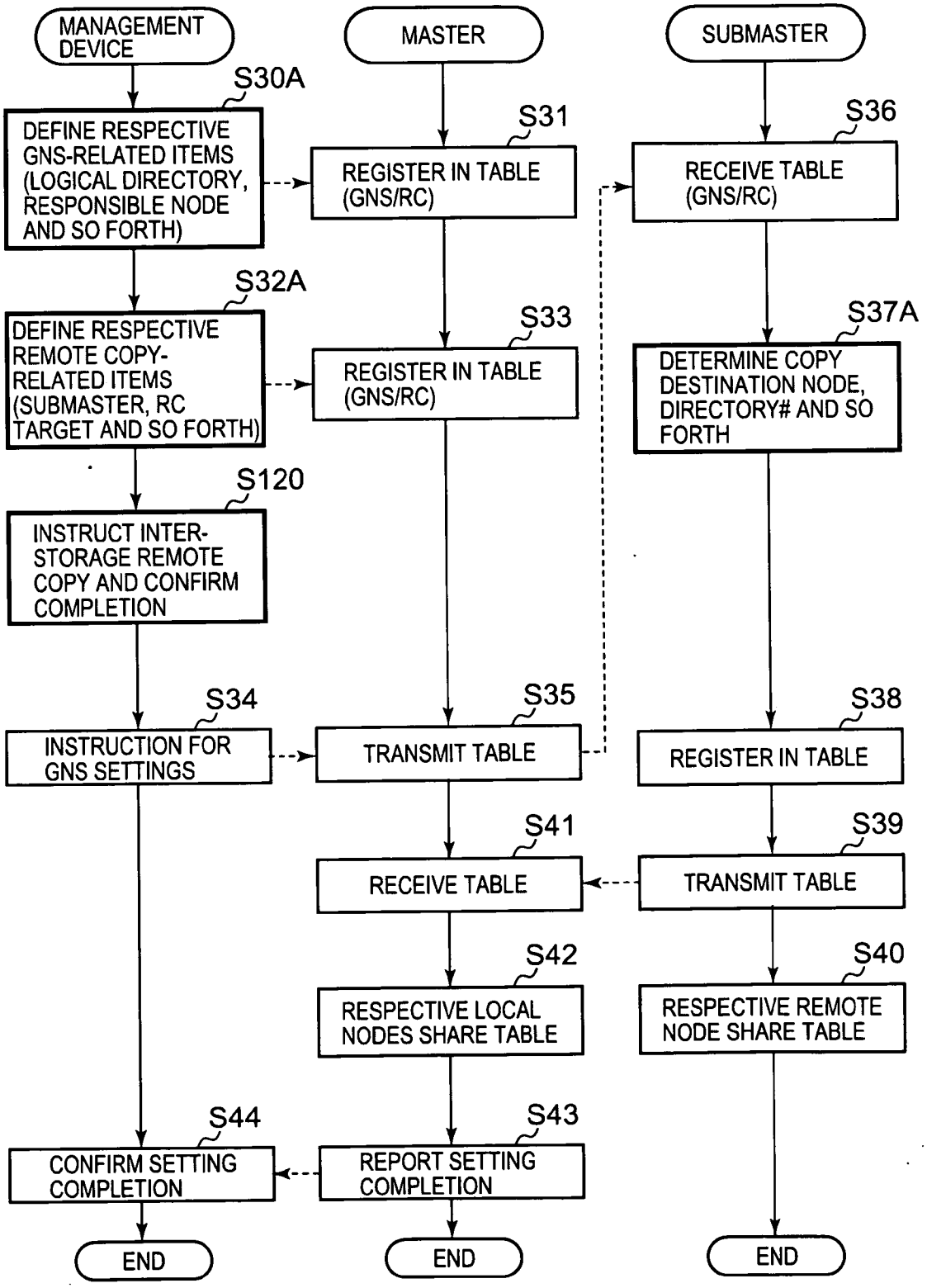

MANAGEMENT DEVICE
MASTER
SUBMASTER
S30A
DEFINE RESPECTIVE GNS-RELATED ITEMS (LOGICAL DIRECTORY, RESPONSIBLE NODE AND SO FORTH)
S31
REGISTER IN TABLE (GNS/RC)
S36
RECEIVE TABLE (GNS/RC)
S32A
DEFINE RESPECTIVE REMOTE COPY-RELATED ITEMS (SUBMASTER, RC TARGET AND SO FORTH)
S33
REGISTER IN TABLE (GNS/RC)
S37A
DETERMINE COPY DESTINATION NODE, DIRECTORY# AND SO FORTH
S120
INSTRUCT INTER-STORAGE REMOTE COPY AND CONFIRM COMPLETION
S34
INSTRUCTION FOR GNS SETTINGS
S35
TRANSMIT TABLE
S38
REGISTER IN TABLE
S41
RECEIVE TABLE
S39
TRANSMIT TABLE
S42
RESPECTIVE LOCAL NODES SHARE TABLE
S40
RESPECTIVE REMOTE NODE SHARE TABLE
S44
CONFIRM SETTING COMPLETION
S43
REPORT SETTING COMPLETION
END
END
END

FIG. 20

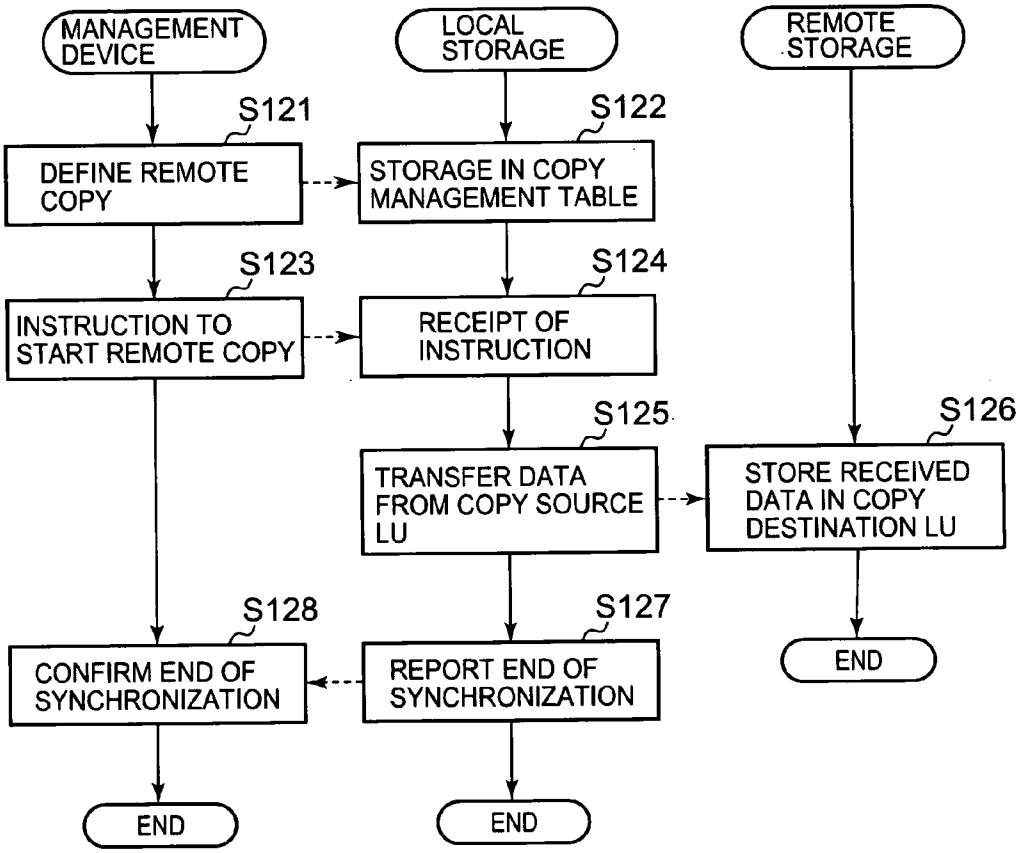

MANAGEMENT DEVICE
LOCAL STORAGE
REMOTE STORAGE
S121
DEFINE REMOTE COPY
S122
STORAGE IN COPY MANAGEMENT TABLE
S123
INSTRUCTION TO START REMOTE COPY
S124
RECEIPT OF INSTRUCTION
S125
TRANSFER DATA FROM COPY SOURCE LU
S126
STORE RECEIVED DATA IN COPY DESTINATION LU
S128
CONFIRM END OF SYNCHRONIZATION
S127
REPORT END OF SYNCHRONIZATION
END
END
END

FIG. 21

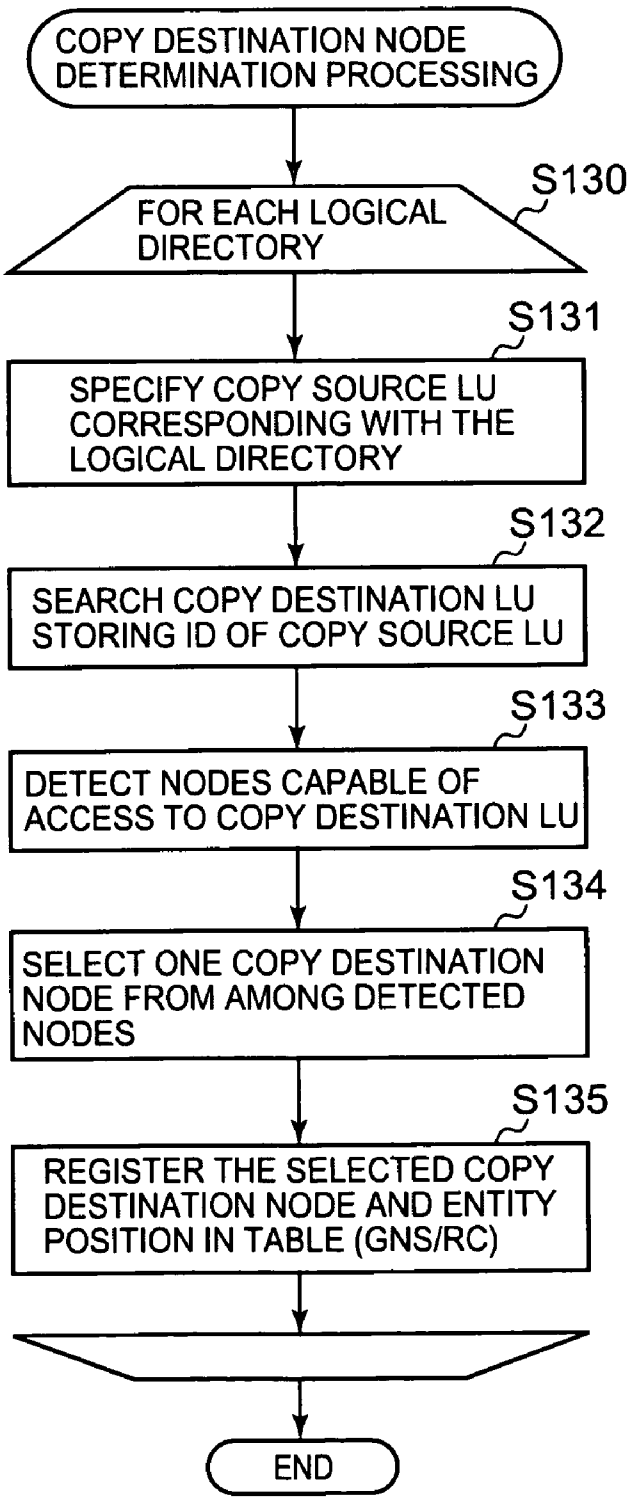

COPY DESTINATION NODE DETERMINATION PROCESSING
S130
FOR EACH LOGICAL DIRECTORY
S131
SPECIFY COPY SOURCE LU CORRESPONDING WITH THE LOGICAL DIRECTORY
S132
SEARCH COPY DESTINATION LU STORING ID OF COPY SOURCE LU
S133
DETECT NODES CAPABLE OF ACCESS TO COPY DESTINATION LU
S134
SELECT ONE COPY DESTINATION NODE FROM AMONG DETECTED NODES
S135
REGISTER THE SELECTED COPY DESTINATION NODE AND ENTITY POSITION IN TABLE (GNS/RC)
END

FIG. 22

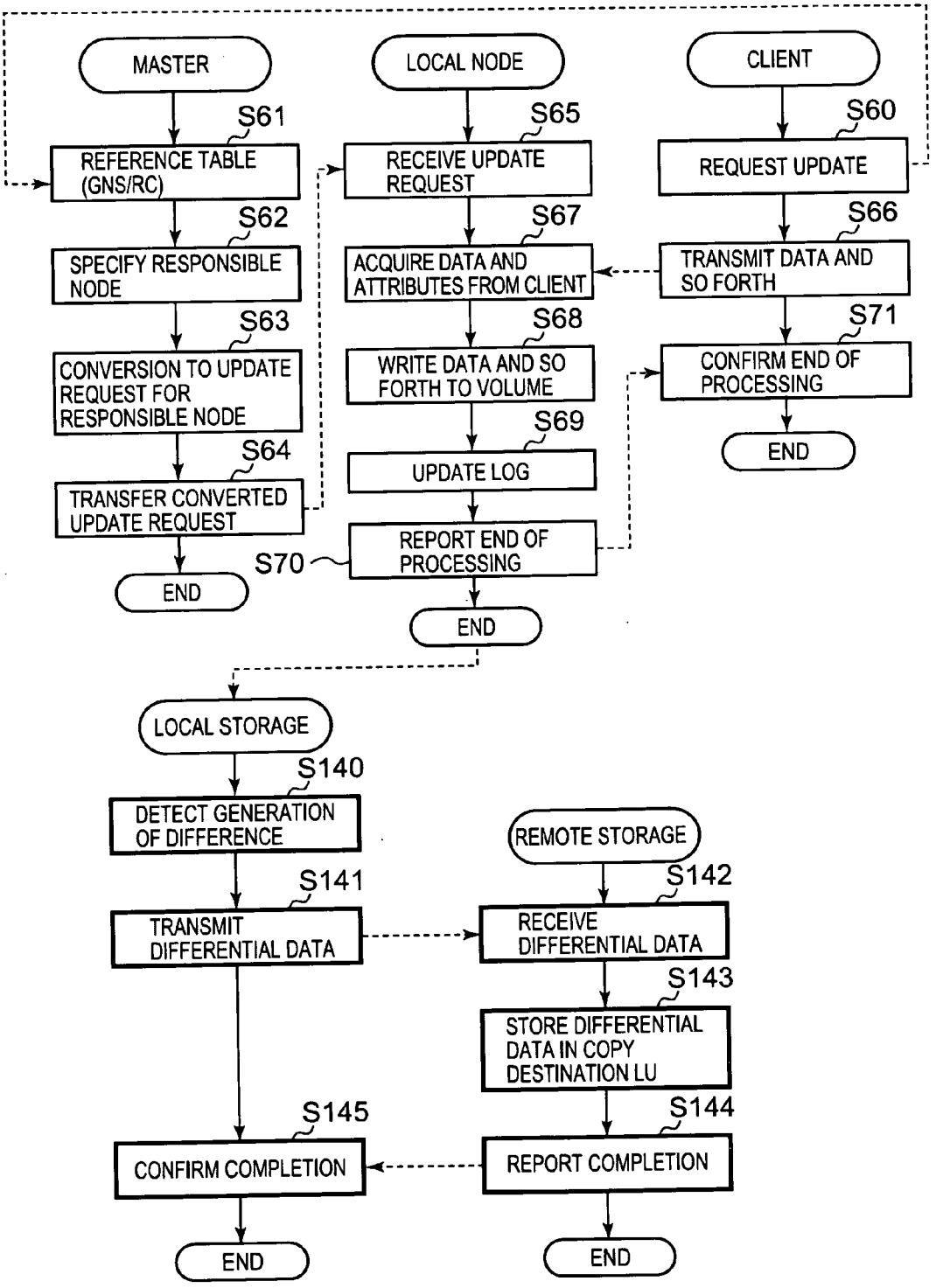

MASTER
S61
REFERENCE TABLE (GNS/RC)
S62
SPECIFY RESPONSIBLE NODE
S63
CONVERSION TO UPDATE REQUEST FOR RESPONSIBLE NODE
S64
TRANSFER CONVERTED UPDATE REQUEST
END
LOCAL NODE
S65
RECEIVE UPDATE REQUEST
S67
ACQUIRE DATA AND ATTRIBUTES FROM CLIENT
S68
WRITE DATA AND SO FORTH TO VOLUME
S69
UPDATE LOG
S70
REPORT END OF PROCESSING
END
CLIENT
S60
REQUEST UPDATE
S66
TRANSMIT DATA AND SO FORTH
S71
CONFIRM END OF PROCESSING
END
LOCAL STORAGE
S140
DETECT GENERATION OF DIFFERENCE
S141
TRANSMIT DIFFERENTIAL DATA
S145
CONFIRM COMPLETION
END
REMOTE STORAGE
S142
RECEIVE DIFFERENTIAL DATA
S143
STORE DIFFERENTIAL DATA IN COPY DESTINATION LU
S144
REPORT COMPLETION
END

FIG. 23

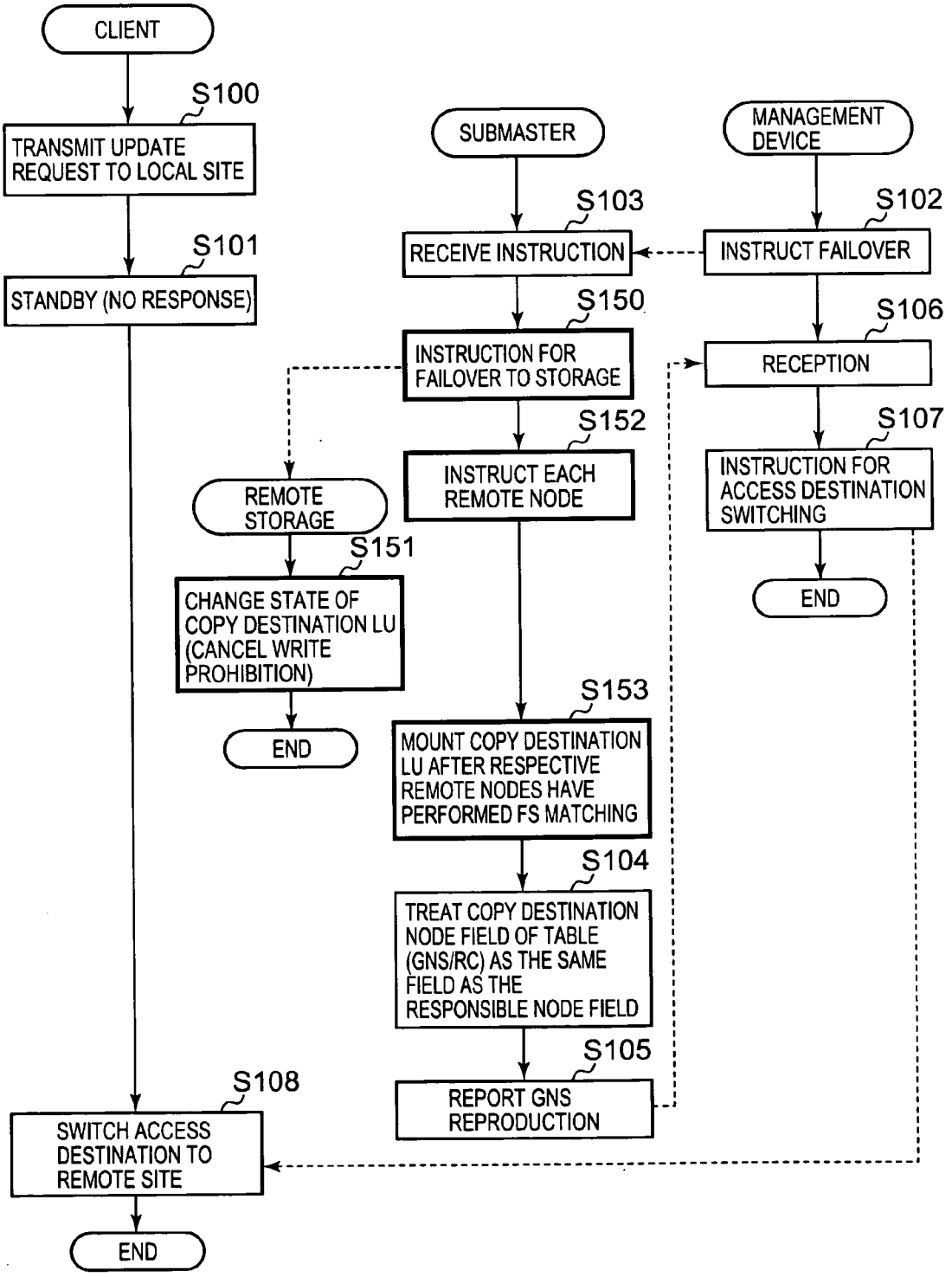

CLIENT
S100
TRANSMIT UPDATE REQUEST TO LOCAL SITE
S101
STANDBY (NO RESPONSE)
SUBMASTER
S103
RECEIVE INSTRUCTION
S150
INSTRUCTION FOR FAILOVER TO STORAGE
S152
INSTRUCT EACH REMOTE NODE
REMOTE STORAGE
S151
CHANGE STATE OF COPY DESTINATION LU (CANCEL WRITE PROHIBITION)
END
S153
MOUNT COPY DESTINATION LU AFTER RESPECTIVE REMOTE NODES HAVE PERFORMED FS MATCHING
S104
TREAT COPY DESTINATION NODE FIELD OF TABLE (GNS/RC) AS THE SAME FIELD AS THE RESPONSIBLE NODE FIELD
S105
REPORT GNS REPRODUCTION
MANAGEMENT DEVICE
S102
INSTRUCT FAILOVER
S106
RECEPTION
S107
INSTRUCTION FOR ACCESS DESTINATION SWITCHING
END
S108
SWITCH ACCESS DESTINATION TO REMOTE SITE
END

FIG. 24

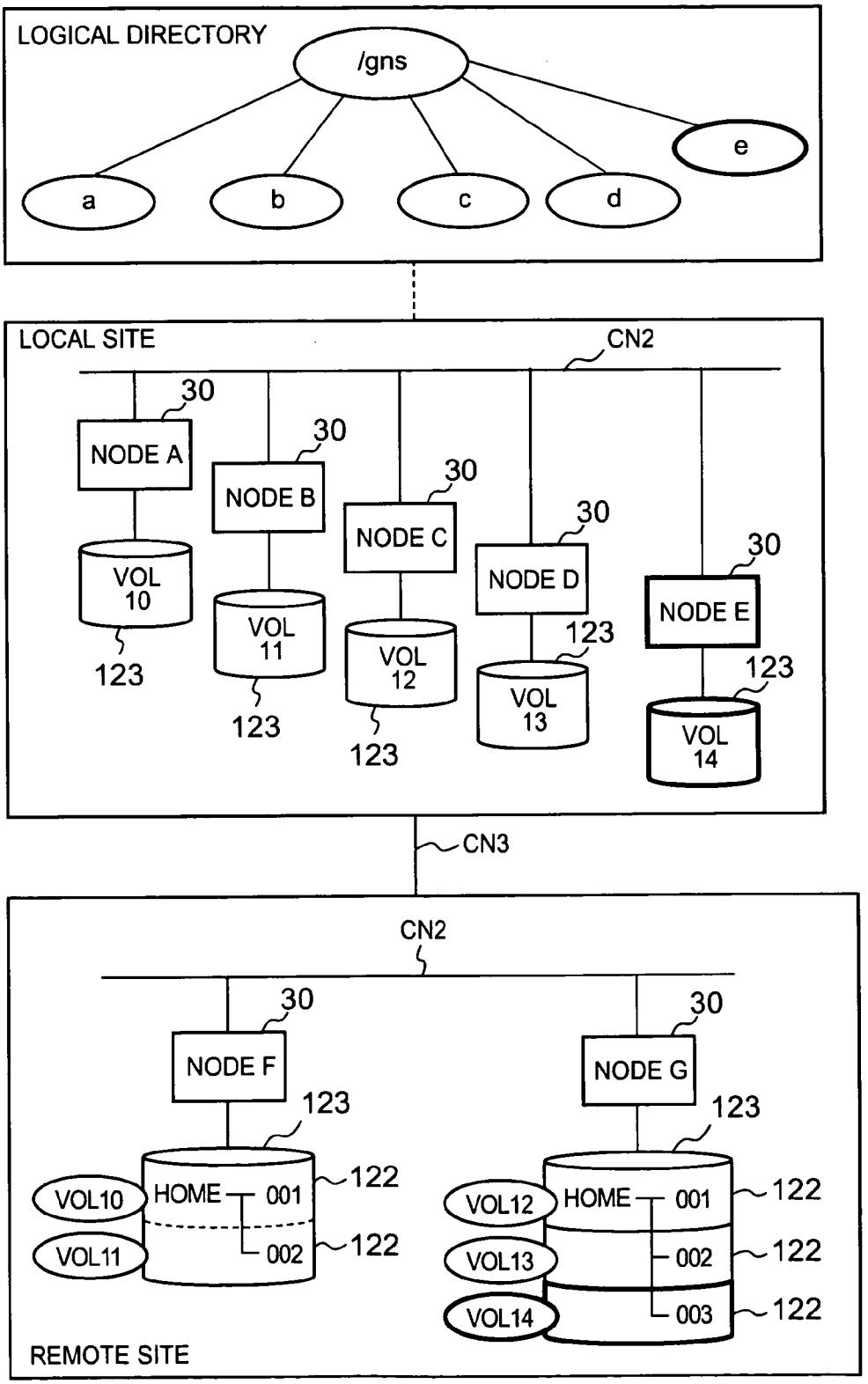

LOGICAL DIRECTORY
/gns
a
b
c
d
e
LOCAL SITE
CN2
30
NODE A
NODE B
NODE C
NODE D
NODE E
VOL 10
VOL 11
VOL 12
VOL 13
VOL 14
123
CN3
CN2
NODE F
NODE G
HOME
001
002
003
122
VOL10
VOL11
VOL12
VOL13
VOL14
REMOTE SITE

FIG. 25

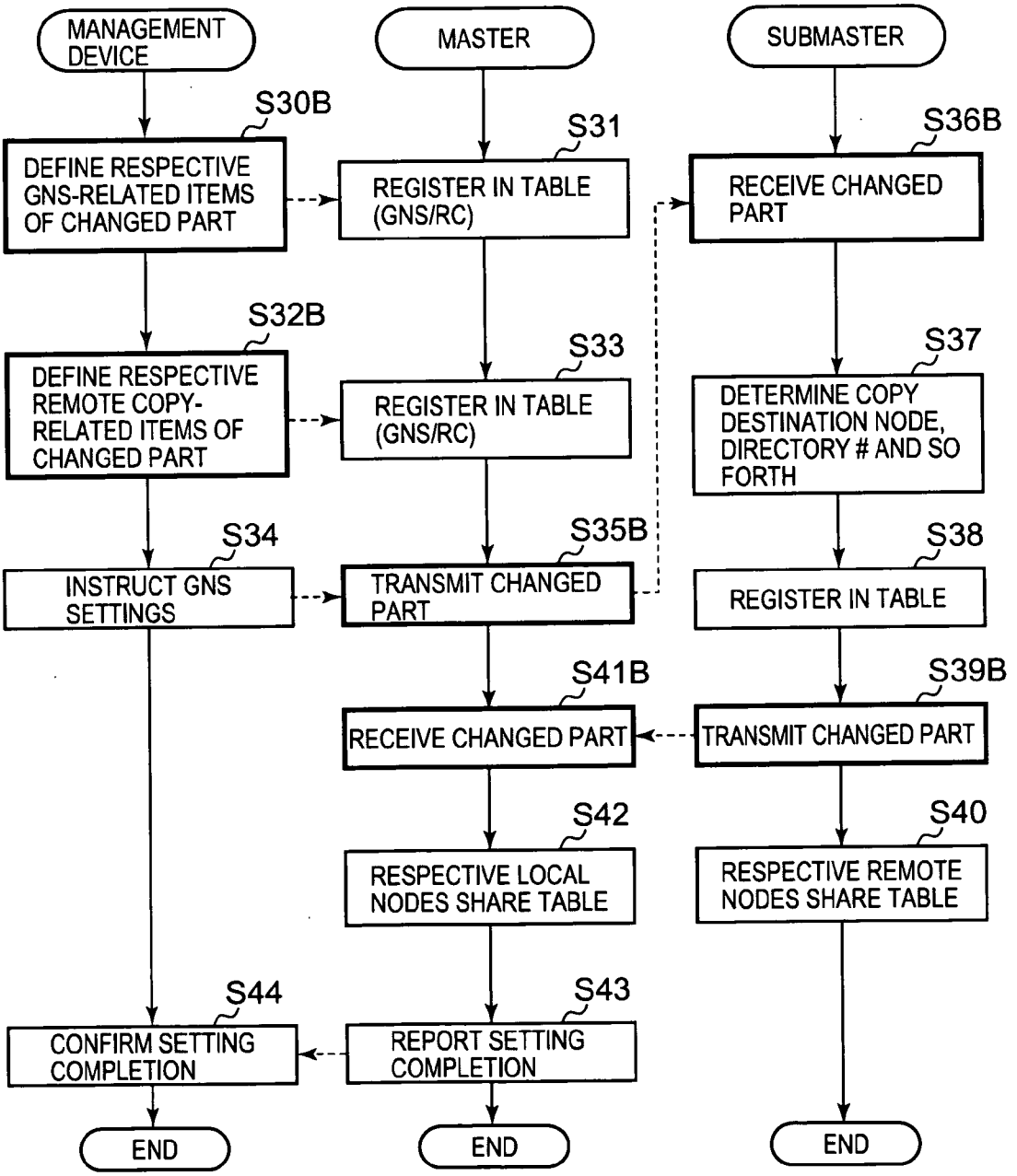

MANAGEMENT DEVICE
MASTER
SUBMASTER
S30B
DEFINE RESPECTIVE GNS-RELATED ITEMS OF CHANGED PART
S31
REGISTER IN TABLE (GNS/RC)
S36B
RECEIVE CHANGED PART
S32B
DEFINE RESPECTIVE REMOTE COPY-RELATED ITEMS OF CHANGED PART
S33
REGISTER IN TABLE (GNS/RC)
S37
DETERMINE COPY DESTINATION NODE, DIRECTORY # AND SO FORTH
S34
INSTRUCT GNS SETTINGS
S35B
TRANSMIT CHANGED PART
S38
REGISTER IN TABLE
S41B
RECEIVE CHANGED PART
S39B
TRANSMIT CHANGED PART
S42
RESPECTIVE LOCAL NODES SHARE TABLE
S40
RESPECTIVE REMOTE NODES SHARE TABLE
S44
CONFIRM SETTING COMPLETION
S43
REPORT SETTING COMPLETION
END
END
END

FIG. 26

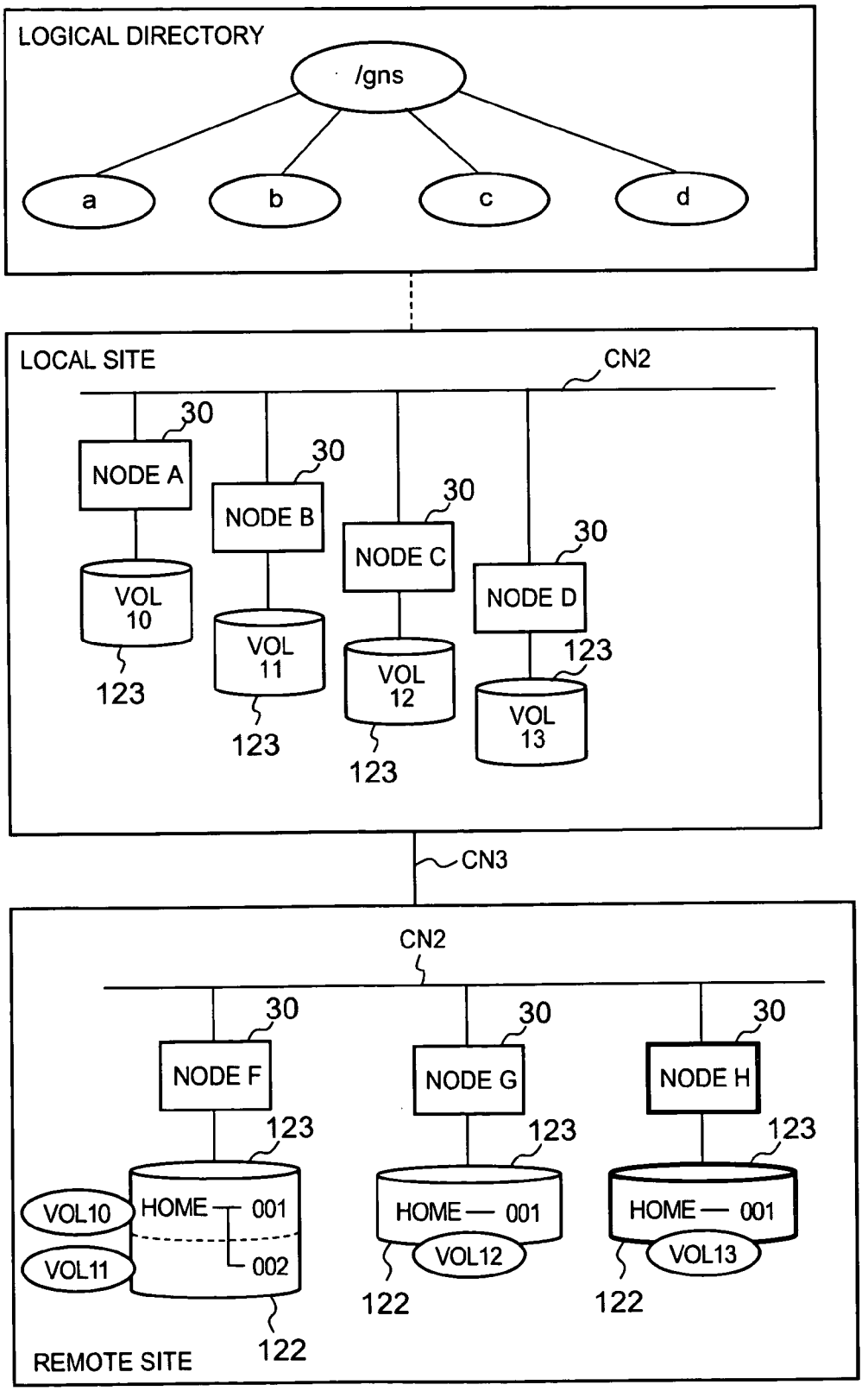
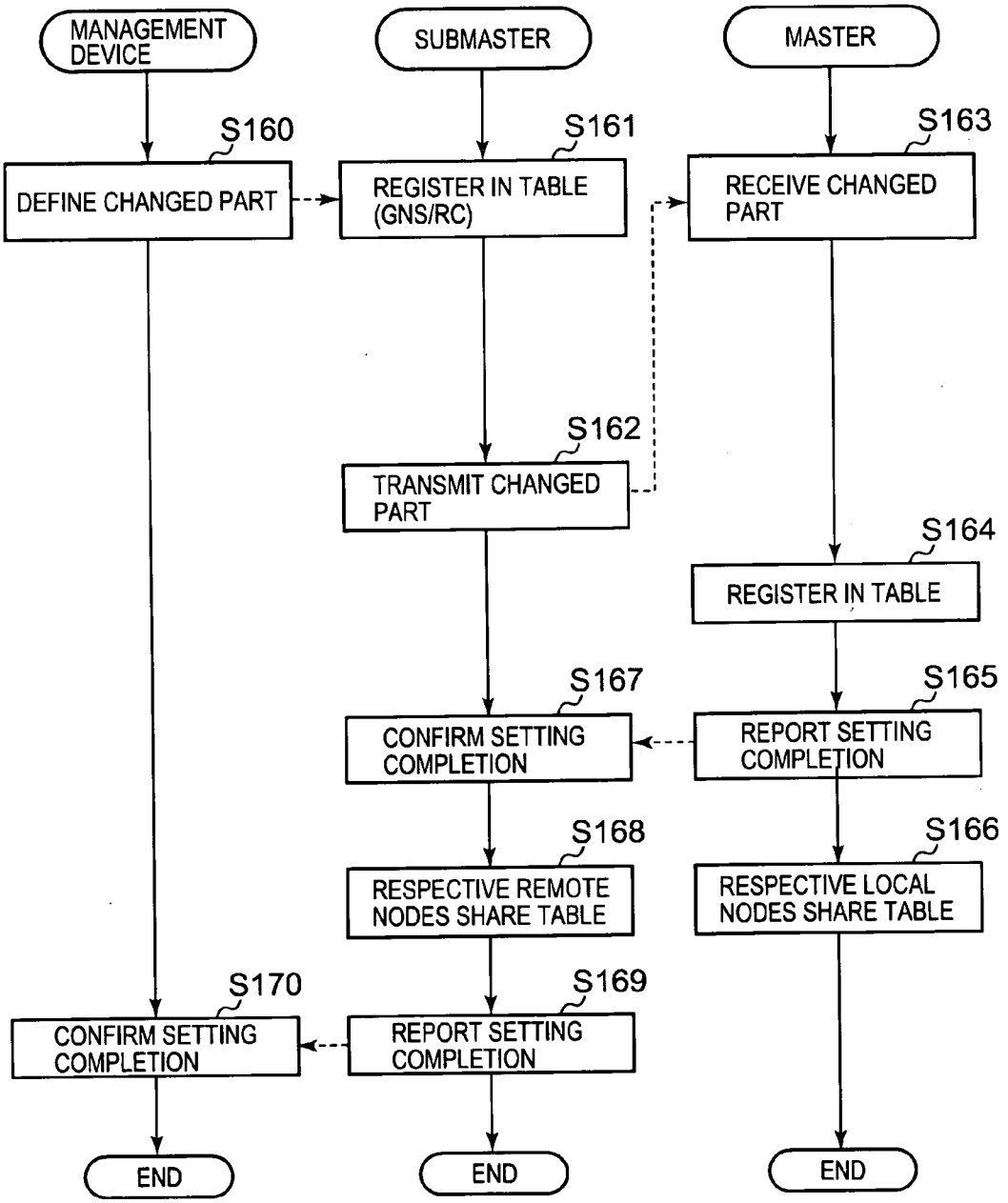

LOGICAL DIRECTORY
/gns
a
b
c
d
LOCAL SITE
CN2
30
NODE A
NODE B
NODE C
NODE D
VOL 10
VOL 11
VOL 12
VOL 13
123
CN3
CN2
NODE F
NODE G
NODE H
VOL10
VOL11
HOME
001
002
VOL12
VOL13
122
REMOTE SITE

FIG. 27


MANAGEMENT DEVICE
SUBMASTER
MASTER
S160
DEFINE CHANGED PART
S161
REGISTER IN TABLE (GNS/RC)
S163
RECEIVE CHANGED PART
S162
TRANSMIT CHANGED PART
S164
REGISTER IN TABLE
S167
CONFIRM SETTING COMPLETION
S165
REPORT SETTING COMPLETION
S168
RESPECTIVE REMOTE NODES SHARE TABLE
S166
RESPECTIVE LOCAL NODES SHARE TABLE
S170
CONFIRM SETTING COMPLETION
S169
REPORT SETTING COMPLETION
END
END
END

FILE-SHARING SYSTEM AND METHOD OF USING FILE-SHARING SYSTEM TO GENERATE SINGLE LOGICAL DIRECTORY STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application relates to and claims priority from Japanese Patent Application No. 2007-160959 filed on Jun. 19, 2007, the entire disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a file sharing system and a method of using the file sharing system to generate a single logical directory structure.

[0004] 2. Description of the Related Art

[0005] In order to share data between a plurality of computers that are distributed on a network, a file-sharing device known as NAS (Network Attached Storage) is used. Data are produced on a daily basis while the client terminals that utilize the data also increase. Hence, data of a large volume must be managed by using a plurality of NAS.

[0006] However, when accessing a desired file, a user must specify a physical NAS in which the file is stored and must access the NAS. In other words, even when the user knows the file name, unless the user knows the physical storage location of the file, it is not possible to access the file.

[0007] Therefore, only when a certain file is moved from a first NAS to a second NAS is it necessary to notify each user of the movement of the file. In addition, in cases where the NAS is added in order to improve the performance, an obsolete NAS is switched for a new NAS and the number of client terminals increases, for example, which is time-consuming for the system administrator. Therefore, in recent years, a system that generates a single logical directory structure by virtualizing the directory structures of the respective NAS has been proposed (Japanese Application Laid Open No. 2007-35030, Japanese Application Laid Open No. 2003-58408, U.S. Patent Application Number 2006/0010169).

[0008] In the prior art, the directory structures of a plurality of NAS are virtualized as a single logical directory structure and supplied to a client terminal. Hence, even when a physical NAS increase or reduction or the like occurs, this does not affect the logical directory structure. As a result, the user is able, by using the logical directory name used thus far, to access the desired file without consideration of the change to the physical constitution.

[0009] However, such patents are lacking with respect to disaster recovery. In a system where disaster recovery is considered, data are synchronized at a plurality of sites and, even when a first site stops due to a fault, access to a file at the second site is possible. Such patents do not disclose a system constitution that considers disaster recovery and, therefore, there is a margin for improvement with respect to fault tolerance.

SUMMARY OF THE INVENTION

[0010] The present invention was conceived in view of the above problems and an object thereof is to provide a file sharing system and a method of using the file sharing system to generate a single logical directory structure in order to be able to increase the fault tolerance. A further object of the present invention is to provide a file sharing system that is able to reproduce a single logical directory structure at a backup site when a fault occurs by synchronizing data between a plurality of sites with mutually different structures and to provide a method of using the file sharing system to generate a single logical directory structure. Yet another object of the present invention is to provide a file sharing system that is constituted to be able to reproduce a single logical directory structure relatively rapidly at a site with a different physical constitution when a fault occurs by integrating management information that is used to generate a single logical directory structure and management information that is used for copy control, as well as a method of using the file sharing system to generate the single logical directory. Further objects of the present invention will become evident from the description of the embodiments that will be provided subsequently.

[0011] In order to achieve the above object, a file sharing system having a first site and a second site according to the present invention is a file sharing system, wherein a plurality of first file sharing devices in the first site and a plurality of second file sharing devices in the second site are connected to enable mutual communication via a first communication path capable of data communication in file units, the system comprising: a logical directory supply section which, by using first management information for managing associated relationship between a single logical directory structure that is generated across the respective first file sharing devices and a first directory structure that the respective first file sharing devices comprise, supplies the logical directory structure that is formed by virtually integrating the respective first directory structures to a client device; a copy control section which, by using second management information for managing associated relationship between storage positions of the data managed by the respective first file sharing devices and storage positions of the data managed by the respective second file sharing devices, transmits and copies copy target data among the data stored in the respective first file sharing devices to second file sharing devices that are associated with the respective first file sharing devices; and a reproduction section which reproduces the logical directory structure that is formed by virtually integrating the respective second directory structure by using the first management information and the second management information in cases where a fault occurs at the first site.

[0012] According to an embodiment of the present invention, the structure of the volume used by the respective first file sharing devices to input and output data and the structure of the volume used by the respective second file sharing devices to input and output data are different.

[0013] According to an embodiment of the present invention, the first management information includes respective directory names of the logical directory structures, responsibility information for specifying predetermined first file sharing devices that are responsible for the respective directory names; and first storage position information for indicating the storage position of the data managed by the predetermined respective first file sharing devices; and the second management information includes the first storage position information, second storage position information for indicating the storage position of data managed by the respective second file sharing devices, and copy destination device

information for specifying second file sharing devices that are associated with the predetermined first file sharing devices.

[0014] According to an embodiment of the present invention, the first management information and the second management information are stored in a common management table; the management table is constituted comprising respective directory names of the logical directory structures, responsibility information for specifying predetermined first file sharing devices that are each responsible for the respective directory names, first storage position information indicating the storage position of data managed by the respective predetermined first file sharing devices, copy destination device information for specifying predetermined second file sharing devices that each correspond with the respective predetermined first file sharing devices, and second storage position information indicating the storage positions of data managed by the respective second file sharing devices, and wherein the reproduction section reproduces the logical directory structures by treating the copy destination device information as the responsibility information in cases where a fault has occurred.

[0015] According to an embodiment of the present invention, the copy control section transmits and copies the copy target data from the first file sharing devices to the second file sharing devices via the first communication path.

[0016] According to an embodiment of the present invention, the respective first file sharing devices store and manage data in a first volume provided by a first storage device in the first site; the respective second file sharing devices store and manage data in a second volume provided by a second storage device in the second site; the first storage device and the second storage device are connected to enable mutual communication via a second communication path that is capable of data communication in block units; and the copy control section transfers and copies the copy target data from the first volume to the second volume via the second communication path.

[0017] According to an embodiment of the present invention, the second volume stores copy source volume identification information for identifying the first volume associated as the copy source with the second volume; and the reproduction section reproduces the logical directory structure that is formed by virtually integrating the respective second directory structure by using the copy source volume identification information, the first management information, and the second management information.

[0018] According to an embodiment of the present invention, the respective first file sharing devices and the respective second file sharing devices hold the first management information and the second management information; and, in cases where either the first site or the second site undergoes a change to the logical directory structure or a copy-related structure, differential information related to structural change is reported to the respective first file sharing devices and the respective second file sharing devices and the differential information is reflected in the first management information or the second management information held by the respective first file sharing devices and the respective second file sharing devices.

[0019] A method of generating a single logical directory structure by using a file sharing system according to another aspect of the present invention, the file sharing system having a first site having a plurality of first file sharing devices, a second site having a plurality of second file sharing devices, and a first communication path that is connected such that the respective first file sharing devices and the respective second file sharing devices are able to perform data communication in file units, the method comprising the steps of: setting first management information for managing associated relationship between a single logical directory structure which is generated across the respective first file sharing devices and a first directory structure that the respective first file sharing devices comprise; providing a client device with a logical directory structure that is made by using the first management information to virtually integrate the respective first directory structures; setting second management information for managing associated relationship between storage positions of data managed by the respective first file sharing devices and storage positions of data managed by the respective second file sharing devices; transmitting and copying copy target data among the data that are stored in the respective first file sharing devices to second file sharing devices that are associated with the respective first file sharing devices by using the second management information; detecting whether a fault has occurred at the first site; and reproducing the logical directory structure that is formed by virtually integrating the respective second directory structure by using the first management information and the second management information in cases where the occurrence of a fault is detected.

[0020] A file sharing system having a first site and a second site according to yet another aspect of the present invention, wherein (1) the first site comprises: (1-1) a plurality of first file sharing devices each having a first directory structure; (1-2) a first storage device which is connected via a first intra-site communication network to the respective first file sharing devices and which supplies a first volume to the first file sharing devices respectively; and (1-3) a master device that issues a predetermined report to the first file sharing devices respectively; and (2) the second site comprises: (2-1) a plurality of second file sharing devices each having a second directory structure and being provided in a number that differs from the number of first file sharing devices; (2-2) a second storage device which is connected via a second intra-site communication network to the respective second file sharing devices and which supplies a second volume to the second file sharing devices respectively; and (2-3) a submaster device that issues a predetermined report to the second file sharing devices respectively; (3) the respective first file sharing devices and the respective second file sharing devices are connected via a first communication path that is capable of data communication in file units and the first storage device and the second storage device are connected via a second communication path that is capable of data communication in block units; (4) the respective first file sharing devices, the respective second file sharing devices, the master device, and the submaster device each hold a management table and the management table is constituted comprising respective directory names that correspond to the respective node names of the logical directory structure, responsibility information for specifying predetermined first file sharing devices responsible for each of the directory names, first storage position information indicating storage positions of data managed by the respective predetermined first file sharing devices, copy destination device information for specifying predetermined second file sharing devices each corresponding to the respective predetermined first file sharing devices, and second storage position information indicating storage positions of data managed by the respective predetermined second file sharing

devices; (5) the master device generates a single logical directory structure that is generated across the respective first file sharing devices by using the management table and supplies the single logical directory structure to a client device; (6) the respective first file sharing devices transmit data that are stored in the first volume to the respective second file sharing devices via the first communication path by using the management table and store the data in the second volume; and (7) the submaster device reproduces the logical directory structure by means of a second directory structure that the respective second file sharing devices comprise by treating the copy destination device information in the management table as the responsibility information in cases where the execution of a failover is instructed.

[0021] At least some of the respective parts and steps of the present invention can sometimes be implemented by a computer program. Such a computer program is stored in a logical device or distributed via a communication network, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** is an explanatory diagram that provides an overview of the file sharing system according to an embodiment of the present invention;

[0023] FIG. **2** is an explanatory diagram showing the overall constitution of the file sharing system;

[0024] FIG. **3** is an explanatory diagram showing the hardware constitution in one site;

[0025] FIG. **4** is an explanatory diagram showing the relationships between a logical directory and the respective nodes, or the like;

[0026] FIG. **5** is an explanatory diagram showing the constitution of the management table that is used for the architecture of the logical directory and in order to execute a remote copy;

[0027] FIG. **6** is an explanatory diagram showing an aspect that changes the method of using the management table in cases where a fault occurs in a local site;

[0028] FIG. **7** is an explanatory diagram showing another example of a management table;

[0029] FIG. **8** is an explanatory diagram showing a system constitution management table;

[0030] FIG. **9** is a flowchart showing the processing for storing the system constitution management table for each node;

[0031] FIG. **10** is a flowchart showing the processing for storing a table that manages a logical directory and remote copy for each node;

[0032] FIG. **11** is a flowchart showing file access request processing;

[0033] FIG. **12** is a flowchart showing the details of the processing indicated by S**47** in FIG. **10**;

[0034] FIG. **13** is a flowchart showing disaster recovery processing;

[0035] FIG. **14** is an explanatory diagram showing the overall constitution of the file sharing system according to a second embodiment;

[0036] FIG. **15** is an explanatory diagram showing the constitution in one site;

[0037] FIG. **16** is an explanatory diagram showing the relationship between a copy source logical device and a copy destination logical device;

[0038] FIG. **17** is an explanatory diagram of a table for controlling a remote copy that is executed between storage devices;

[0039] FIG. **18** is an explanatory diagram of a management table that is used for the architecture of a logical directory and for a remote copy;

[0040] FIG. **19** is a flowchart showing the processing for reporting the management table to each node;

[0041] FIG. **20** is a flowchart showing remote copy processing between storage devices;

[0042] FIG. **21** is a flowchart showing the details of the processing indicated by S**37**A in FIG. **19**;

[0043] FIG. **22** is a flowchart showing processing for copying differential data between storage devices;

[0044] FIG. **23** is a flowchart showing disaster recovery processing;

[0045] FIG. **24** is an explanatory diagram showing an aspect in which the constitution of a local site is changed by a file sharing system according to a third embodiment;

[0046] FIG. **25** is a flowchart showing processing to reflect changes in the constitution of the local site in the management table in each node;

[0047] FIG. **26** is an explanatory diagram showing an aspect in which the constitution of the remote site is changed by a file sharing system according to a fourth embodiment; and

[0048] FIG. **27** is a flowchart showing processing to reflect changes to the constitution of a local site in a management table in each node.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0049] FIG. **1** is an explanatory diagram that provides an overview of the file sharing system according to an embodiment of the present invention. The file sharing system shown in FIG. **1**A comprises a first site **1** and a second site **2**, for example, and a 'file sharing device' NAS node (sometimes abbreviated as 'node' hereinbelow) **3** and a volume **4** are each provided in the respective sites **1** and **2**. Each NAS node **3**, management device **5**, and client device ('client' hereinbelow) **6** are connected so as to each be capable of mutual communication via a first communication path **9** that is capable of data communication in file units.

[0050] The first site **1** can be called a local site or main site and each client **6** is provided with a single logical directory **8**. The logical directory **8** is made by virtually integrating the directory trees of the respective NAS nodes **3** in the first site **1** and the client **6** is able to access a file in logical directory **8** without being aware of the actual storage location of the file. For example, by making the names corresponding to the node names of the logical directories department names such as 'accounting department' and 'development headquarters', the user is able to access the required file without being completely aware of which NAS node the actual file group is stored in. The technology for generating a single logical directory is known as GNS (Global Name Space). Further, the GNS can be based on the technology disclosed in US2006-0010169A1 (U.S. patent application Ser. No. 10/886,892).

[0051] As mentioned above, the first site **1** is a site that provides each client **6** with a logical directory **8** and the second site **2** is a remote site (or backup site) that is provided in cases where the first site **1** has stopped. Each node **3** (N**1**, N**2**) in the first site **1** is able to use the volume **4**. Volume **4** is

provided by a storage device such as a disk array device, for example, as will become evident from the subsequent embodiment.

[0052] For example, at least one node **3** (N**1**, for example) among the respective nodes **3** in the first site **1** can be used as a master node. The master node **3** (N**1**) converts, by using a table T, a file access request that is issued by the client **6** into a file access request for a storage destination node **3** (N**2**, for example) that actually stores the requested file and transfers the converted file access request to the storage destination node **3** (N**2**).

[0053] In cases where the file access request is a request for write access, the storage destination node **3** (N**2**) directly receives write data from the client **6** and writes same to the volume **4** which is under the management of the storage destination node **3** (N**2**).

[0054] Thus, the master node **3** (N**1**) possesses a function for representatively receiving the access request from the client **6** and transferring the access request to a node (also called the responsible node) that actually stores the access destination file. As a result, the client **6** is provided with a single logical directory **8**. The actual processing with respect to the file access request is carried out by the responsible node **3** (N**2**) and the processing result is transmitted directly from the responsible node **3** (N**2**) to the client **6**. When the access destination file is stored in volume **4** of the master node **3** (N**1**), the master node **3** (N**1**) processes file access with the master node **3** (N**1**) itself serving as the responsible node.

[0055] The master node **3** (N**1**) performs work to manage the relationship between file access requests from the client **6** (access path) and the actual responsible node **3** (N**2**) and distribute the access requests to the responsible node **3** (N**2**). Hence, for example, although different depending on the number of clients **6** and the processing function and so forth of the node, the processing load of the master node **3** (N**1**) may be thought of as being higher than that of the other node **3** (N**2**). Therefore, the master node **3** (N**1**) need not comprise volume **4** and may be dedicated to the provision of a logical directory **8**. In addition, in cases where a fault occurs with master node **3** (N**1**), another node **3** (N**2**) in the first site **1** can also be preset as a second master node.

[0056] Similarly to the first site **1**, the second site **2** comprises NAS node **3** and volume **4**. Although, for the sake of convenience of the paper, the second site **2** shows only one node **3** (N**3**) but, as will also be evident from the subsequent embodiments, a plurality of nodes **3** can actually be provided in the second site **2**.

[0057] The second site **2** is a backup site that is provided in cases where the first site **1** has stopped. The second site **2** stores the same file group as the file group managed by the respective nodes **3** (N**1**, N**2**) in the first site **1**, in volume **4** in the second site **2**. That is, a remote copy is made by taking the respective nodes **3** (N**1**, N**2**) in the first site **1** as the copy source nodes and the node **3** (N**3**) in the second site **2** as the copy destination node.

[0058] A remote copy is made in file units via a first communication path **9** such as the Internet or LAN (Local Area Network), for example. By creating a plurality of directories in one volume **4**, the copy destination node **3** (N**3**) is able to collectively hold a plurality of copy source directories in one volume **4**.

[0059] That is, in the example shown in FIG. **1**, the directory of the first copy source node **3** (N**1**) is associated with a first directory (/Home/001) of the copy destination node **3** (N**3**) and the directory of the other copy source node **3** (N**2**) is associated with a second directory (/Home/002) of the copy destination node **3** (N**3**). The copy destination node **3** (N**3**) can receive and save data from the plurality of copy source nodes **3** (N**1** and N**2**) by preparing a plurality of copy destination directories.

[0060] In other words, the constitution of the physical resources in the first site **1** and the constitution of the physical resources in the second site **2** differ. Generally speaking, the second site **2** is created with a smaller physical resource amount than the first site **1**. This is because the second site **2** is a backup site and in order to reduce the overall cost of the system.

[0061] The respective nodes **3** of the respective sites **1** and **2** share management table T. In other words, all of the nodes **3** in the system save the same management table T. An overview of the constitution of table T is shown in FIG. **1**B.

[0062] Management table T comprises GNS management information and copy management information, for example. GNS management information is information that is required in order to construct a logical directory **8** and is constituted comprising, for example, information for specifying the directory name of the logical directory and the node responsible for the directory as well as information indicating the positions in which the file groups managed by the directory are really stored (shown as 'entities' in FIG. **1**B).

[0063] The copy management information is information that is required in order to copy and store a copy target file group that is in the first site **1** in the second site **2**. The copy management information is constituted comprising, for example, information for specifying the copy source node, information for specifying the whereabouts of copy target data, information for specifying the copy destination node, and information indicating the storage destination of the copy target data (shown as 'entity' in FIG. **1**B).

[0064] The 'responsible node' that is used by the GNS management information corresponds to the copy source node. Information indicating the whereabouts of the copy target data corresponds to 'entity' which is used by the GNS management information. Hence, the management table T integrates and manages GNS management information and copy management information.

[0065] As mentioned earlier, the master node **3** (N**1**) converts a file access request from client **6** on the basis of the GNS management information in the management table T into a file access request that is used for the responsible node and transfers the converted file access request. The respective nodes **3** (N**1** and N**2**) in the first site **1** transmit and copy target data to a predetermined directory of the copy destination node by using management table T.

[0066] If a disaster befalls the first site **1** and same stops, operational processing is continued by using the second site **2**. The submaster node **3** (N**3**) in the second site **2** reproduce the logical directory **8** in the second site **2** on the basis of an explicit instruction from the management device **5**, for example. As mentioned earlier, in order to construct logical directory **8**, information for specifying the directory name of the logical directory and the node that is responsible for the directory and information indicating the position in which the file group managed by the directory is actually stored is required.

[0067] As shown at the bottom of FIG. **1**B, in cases where a fault occurs in the first site **1**, the submaster node **3** (N**3**) handles the 'copy destination node' of the copy management

information as information that is the same as the 'responsible node'. As a result, the client **6** is able to request file access on the basis of the logical directory **8** and the file access request can be processed by using a file group that is saved in the second site **2**.

[0068] In other words, by using the management table T that is used in both the GNS management and the copy management, by handling 'copy destination node' as the responsible node, all of the information required to reproduce the logical directory **8** can be obtained.

[0069] In this embodiment that is constituted in this manner, by utilizing a remote copy that is executed between the respective sites **1** and **2**, a logical directory **8** can be reproduced at the second site **2** when the first site **1** is stopped.

[0070] In other words, in this embodiment, a plurality of sites **1** and **2** are corrected by a first communication path **9** and data in the first site **1** and data in the second site **2** are synchronized beforehand and, in cases where a fault occurs at the first site **1**, a logical directory **8** can be reproduced in the second site **2**. Therefore, logical directory **8** can be provided by improving the fault tolerance even in cases where the constitution of the physical resources between the respective sites **1** and **2** is different.

[0071] In this embodiment, management table T, which integrates the GNS management information and copy management information, is employed and, in cases where a fault occurs at the first site **1**, the logical directory **8** can be reproduced at the second site **2** relatively rapidly by treating part of the copy management information (information indicating the storage destination of the copy target data and information specifying the copy destination node) as part of the GNS management information (information for specifying the responsible node and information indicating the storage destination of the real data). Embodiments of the present invention will be described in detail hereinbelow.

First Embodiment

[0072] FIG. **2** is an explanatory diagram indicating the overall constitution of the file sharing system according to this embodiment. In this system, the local site **10** and remote site **20** are connected via an inter-site network CN**3** such as a LAN or the Internet, for example.

[0073] The respective sites **10** and **20** can each comprise a plurality of NAS nodes **30**, a switch **40**, a management device **50**, and a storage device **100**, and so forth, for example. The respective nodes **30** are connected via an intra-site network CN**2**, within the respectively positioned sites. Further, the intra-site network CN**2** within the respective sites **10** and **20** are connected via an intra-site network CN**3**.

[0074] A plurality of clients **60** that use the logical directory to access files are connected to the intra-site network CN**3** (only one is shown). The management device **50** can also be individually provided within each of the sites **10** and **20** and can also be provided in sites spaced apart from the two sites **10** and **20**. The role of the management device **50** will be described subsequently.

[0075] Here, the relationship with FIG. **1** will be described. The local site **10** corresponds to the first site **1** in FIG. **1**; the remote site **20** corresponds to the second site **2** in FIG. **1**; the NAS node **30** corresponds to the NAS node **3** in FIG. **1**; the management device **50** corresponds to the management device **5** in FIG. **1**; and the client **60** corresponds to the client **6** in FIG. **1**. A logical volume **123** corresponds to volume **4** in FIG. **1**, and the subsequently described management table T**10** corresponds to the management table T in FIG. **1**.

[0076] The local site **10** will now be described. The local site **10** normally provides client **60** with GNS. The respective nodes **30** (A to D) in the local site **10** are connected to the storage device (DKC in FIG. **2**) **100** via the switch **40** that is constituted as a Fibre Channel switch, for example. The respective nodes **30** are associated with volume **123** that is provided by the storage device **100**. The respective nodes **30** are able to read and write data to their respective volumes **123** which are allocated thereto.

[0077] The remote site **20** is a site that is provided in cases where a fault occurs in the local site **10**. The respective nodes **30** (F, G) in the remote site **20** are also connected to the storage device **100** via switch **40** in order to use the volumes **123** allocated thereto.

[0078] FIG. **3** is an explanatory diagram that provides a detailed view of the constitution within one site. The NAS node **30** comprises, for example, a microprocessor ('CPU' in FIG. **3**) **31**, a memory **32**, a lower communication interface section (HBA in FIG. **3**) **33**, an upper communication interface ('I/F' in FIG. **3**) **34**, and a user interface section (UI in FIG. **3**) **35**. The respective parts **31** to **35** are connected by a bus **36**.

[0079] Memory **32** is able to store a NAS-OS **32**A, various programs **32**B, and a table T**1**, for example. The NAS-OS **32**A is an operating system for performing file sharing. The various programs **32**B are programs for implementing GNS generation functions and remote copy functions and so forth described subsequently. Table T**1** is a table that is used for GNS generation and remote copies. By executing the OS **32**A, program **32**B, and microprocessor **31**, the NAS node **30** implements file sharing services and so forth.

[0080] The lower communication interface section **33** is for communicating in block units with the storage device **100** on the basis of the Fibre Channel protocol, for example. The upper communication interface **34** is for performing communication in file units with the other NAS nodes **30** and clients **60** based on the TCP/IP (Transmission Control Protocol/Internet Protocol), for example. The user interface section **35** comprises an information output device such as a display device and an information input device such as a keyboard switch, for example.

[0081] The management device **50** is a computer device comprising a management tool **50**A for managing each node **30** and storage device **100**. The management device **50** supplies various instructions (described subsequently) to the respective nodes **30** or is able to change the constitution of the storage device **100**. Possible examples of changes to the constitution of the storage device **100** include the generation and deletion of a volume **123** and changes in the connection destination of volume **123**, for example.

[0082] The storage device **100** is constituted comprising, for example, a controller **110**, a storage device-mount section (HDU in FIG. **3**) **120**, for example. The controller **110** controls the operation of the storage device **100**. The controller **110** is constituted comprising, for example, a plurality of channel adapters ('CHA' hereinbelow) **111**, a plurality of disk adapters (only one is shown in FIG. **3**; called 'DKA' hereinbelow) **112**, a shared memory ('SM' in Figs.) **113**, a cache memory ('CM' hereinbelow) **114**, a connection control section **115**, and a service processor ('SVP' hereinbelow) **116**.

[0083] The CHA **111** is a computer device for performing FCP (Fibre Channel Protocol)-based communications, for

example. The CHA **111** is constituted by one or a plurality of substrates on which a microprocessor and memory are mounted, for example, and the memory stores a program or the like for analyzing and executing FCP-based commands. The CHA **111** comprises at least one or more fibre channel interfaces (displayed as FC-I/F in FIG. **3**) **111**A. The fibre channel interface **111**A has a preset WWN.

[0084] The DKA **112** exchanges data with the disk drives **121** of the HDU **120**. The DKA **112** is constituted as a computer device comprising a microprocessor and memory and so forth as per the CHA **111**. Although one DKA **112** is shown for the sake of convenience in FIG. **3**, a plurality of DKA **112** are actually provided.

[0085] DKA **112** is connected to the respective disk drives **121** in the HDU **120** via a fibre channel. The DKA **112** writes data that have been received by the respective CHA **111** and stored in the cache memory **114** at a predetermined address in a predetermined disk drive **121**. The DKA **112** reads data requested by the respective CHA **111** from a predetermined disk drive **121** and stores the data in the cache memory **114**.

[0086] The DKA **112** converts a logical address into a physical address. A logical address is an address that indicates the block position of a logical volume and is called an LBA (Logical Block Address). A physical address is an address that indicates the write position in the disk drive **121**. The DKA **112** performs data access that corresponds with a RAID configuration in cases where the disk drive **121** is managed in accordance with RAID. For example, the DKA **112** writes the same data to a plurality of disk drives **121** (RAIDl) or executes a parity calculation and distributes and writes the data and parity to the plurality of disk drives **121** (RAIDS or similar).

[0087] The shared memory **113** or the like is memory for storing various management information and control information and so forth that are used in order to control the operation of the storage device **100**. The cache memory **114** is memory for storing data received by the CHA **111** or for storing data which are read from the disk drive **121** by the DKA **112**.

[0088] Any one or a plurality of the disk drives **121** may be used as a cache disk. As shown in FIG. **3**, the cache memory **114** and shared memory **113** may also be constituted as separate memory. Alternatively, a partial storage area of the same memory may be used as the cache area and another storage area may be used as the control area.

[0089] The connection control section **115** mutually connects the CHA **111**, DKA **112**, cache memory **114**, and shared memory **113**. The connection control section **115** is constituted as a crossbar switch or the like that transfers data by means of a high-speed switching operation, for example.

[0090] An SVP **116** is connected to each CHA **111** via a communication network such as a LAN, for example. The SVP **116** is able to access the DKA **112**, cache memory **114**, and shared memory **113** via the CHA **111**, for example. The SVP **116** collects information related to various states in the storage device **100** and supplies this information to the management device **50**. The user is able to learn various states of the storage device **100** via the screen of the management device **50**.

[0091] The SVP **116**, upper communication interface section **34** in each node **30**, and management device **50** are connected so as to be capable of two-way communication via an intra-site network CN**2**. The user is able to set the access path between the NAS device **10** and logical volume, for example, via the SVP **116**, from the management device **50**, generate a logical volume **122**, and delete the logical volume **122**.

[0092] The HDU **120** comprises a plurality of disk drives **121**. Although disk drives are given by way of example in this specification, the present invention is not limited to hard disk drives. For example, various storage devices and equivalents thereof such as semiconductor memory drives (including flash memory devices) and holographic memory can be used. In addition, disks of different types, such as FC (Fibre Channel) disks and SATA (Serial AT Attachment) disks, for example, can also be mixed in the HDU **120**.

[0093] One RAID group (also known as a parity group) can be formed by a plurality of disk drives **121**. A RAID group virtualizes the physical storage area of the respective disk drives **121** in accordance with the RAID level and can be called a physical storage device. A physical storage area of a RAID group can be provided with one or a plurality of logical devices **122** of a predetermined size or optional size. The logical device **122** is displayed as 'LU' in FIG. **3**. By associating one or a plurality of logical devices **122** with a LUN (Logical Unit Number), a logical volume **123** is generated and recognized by the NAS node **30**. When logical volume **123** is always generated by using one logical device **122**, the logical volume **123** and logical volume **122** means substantially the same component. However, one logical volume **123** is sometimes also constituted by a plurality of logical devices **122**.

[0094] The data I/O operation of the storage device **100** will now be explained in simple terms. A read command that is issued by the NAS node **30** is received by the CHA **111**. The CHA **111** stores the read command in the shared memory **113**.

[0095] The DKA **112** references the shared memory **113** as required. Upon discovering an unprocessed read command, the DKA **112** accesses a disk drive **121** that constitutes the logical volume **122** that is designated as a read destination and reads the required data. The DKA **112** performs conversion processing between physical addresses and logical addresses and stores the data read from the disk drive **121** in the cache memory **114**.

[0096] The CHA **111** transmits data that are stored in the cache memory **114** to the NAS node **30**. When data requested by the NAS node **30** are already stored in the cache memory **114**, the CHA **111** transmits data stored in the cache memory **114** to the NAS node **30**.

[0097] A write command that is issued by the NAS node **30** is received by the CHA **111** as in the case of a read command. The CHA **111** stores write data that have been transmitted from the NAS node **30** in the cache memory **114**. The DKA **112** stores write data stored in the cache memory **114** in a disk drive **121** that constitutes the logical volume **122** which has been designated as the write destination.

[0098] Further, the constitution may be such that the end of processing is reported to the NAS node **30** at the point where write data are stored in the cache memory **114** or the constitution may be such that the end of processing is reported to the NAS node **30** after the write data have been written to the disk drive **121**.

[0099] FIG. **4** is an explanatory diagram showing the constitution of the remote copy between the respective sites **10** and **20** and the relationships between the logical directory structure and the respective nodes **30**. FIG. **4**A is an explanatory diagram that shows the constitution of the logical direc-

tory in simplified form. In this embodiment, a case where four directories '/a to /d' are provided below the root directory '/gns' is given as an example.

[0100] FIG. **4**B shows the respective nodes **30** and volumes **123** in local site **10** in simplified form. The respective nodes **30** (A to D) in the local site **10** correspond with the respective directories (/a to /d) of the logical directory. In this embodiment, node **30** (A) is the master node and node **30** (F) is the submaster node.

[0101] FIG. **4**C shows the respective nodes **30** and volumes **123** of remote site **20**. The respective nodes **30** (F, G) in the remote site **20** correspond to copy destination nodes. The nodes **30** (A to D) in the local site **10** each correspond to copy source nodes. The respective copy destination nodes **30** (F, G) are each associated with a plurality of copy source nodes **30**.

[0102] In other words, in this embodiment, the copy destination node **30** (F) is associated with a plurality of copy source nodes **30** (A, B). The copy destination node **30** (F) stores data that are the same as the data managed by the respective copy source nodes **30** (A, B) in the volume **123** which is allocated to the copy destination node **30** (F). Likewise, the copy destination node **30** (G) is associated with a plurality of copy source nodes **30** (C, D). The copy destination node **30** (G) stores the same data as the data managed by the respective copy source nodes **30** (C, D) in the volume **123** which is allocated to the copy destination node **30** (G).

[0103] Directories in a quantity corresponding with the number of copy source nodes are created in the volume **123** allocated to the copy destination node. In volume **123**, which is used by the copy destination node **30** (F), a file group that is managed by the copy source node **30**(A) is stored at '/Home/001' and a file group that is managed by the copy source node **30** (B) is stored at '/Home/002'. Likewise, in volume **123** that is used by copy destination node **30** (G), a file group that is managed by the copy source node **30**(C) is stored at '/Home/001' and a file group that is managed by the copy source node **30** (D) is stored at '/Home/002'.

[0104] A plurality of copy source volumes are associated with the copy destination volume **123**. Hence, the copy destination volume **123** in the remote site **20** may also be constituted by linking a plurality of logical devices **122**. In this case, as will be described subsequently in the fourth embodiment, the constitution of the remote site can be changed with the intention of distributing the access load.

[0105] FIG. **5** is an explanatory diagram of an example of management table T**10** which is used for the generation of a logical directory (GNS) and a remote copy (RC). The management table T**10** associates and manages the logical directory field C**11**, a responsible node field C**12**, an entity position field C**13**, a copy destination node field C**14**, and a copy destination entity position field C**15**, for example.

[0106] The logical directory field C**11** indicates the directory name of a logical directory. The responsible node field C**12** indicates the NAS node **30** that is responsible for the directory. The entity position field C**13** indicates the position in which the data managed by the responsible node are actually stored, that is, the data storage location. The copy destination node field C**14** specifies the node for storing the data (file group) of the respective copy source nodes **30** (A to D) in the local site **10**. As mentioned earlier, the copy destination nodes **30** (F, G) can be associated with a plurality of copy source nodes. In cases where the copy destination nodes **30** (F, G) are associated with a plurality of copy source nodes, a directory is prepared for each of the copy source nodes at the copy destination nodes.

[0107] As shown in the middle of FIG. **5**, in cases where the management table T**10** is defined, all or some of the records of the management table T**10** are transmitted in a state where C**14** and C**15** are blank fields from the local site **10** to the remote site **20**. When the system is initially set, all of the records of the management table T**10** are transmitted from the local site **10** to the remote site **20**. However, in the event of a partial constitutional change, only those records related to the partial constitutional change are transmitted from the local site **10** to the remote site **20**. As shown in the lower part of FIG. **5**, fields C**14** and C**15** are entered for the remote site **20** and all or some of the records of management table T**10** are transmitted from the remote site **20** to local site **10**.

[0108] FIG. **6** is an explanatory diagram that schematically shows an aspect where the treatment of the management table T**10** is changed in cases where a fault occurs at local site **10**. As shown in the upper part of FIG. **6**, in cases where a disaster befalls the local site **10**, the respective responsible nodes **30** (A to D) stop functioning and are no longer able to process a file access request from the client **60**.

[0109] Therefore, as shown in the lower part of FIG. **6**, the remote site **20** reproduces a logical directory (GNS) in the remote site **20** by treating the copy destination node field C**14** as a field with the same information as that of the 'responsible node field'. More precisely, the submaster node **30** (F) in the remote site **20** interrupts the usage of the responsible node field C**12** and entity position field C**13** in the management table T**10** and uses the copy destination node field C**14** and the copy destination entity position field C**15** as the responsible node field C**12** and entity position field C**13**.

[0110] The alternative responsible nodes **30** (F, G) hold the same file groups as the file groups that are managed by the copy source nodes **30** (A to D) which are the original responsible nodes. Therefore, the same logical directory as before the disaster can be reproduced even when responsible nodes corresponding to the directory responsible for the node name of the logical directory are switched from the original responsible nodes **30** (A to D) to the copy destination nodes **30** (F, G).

[0111] FIG. **7** is an explanatory diagram showing another example of the management table T**10**. In addition to the name fields C**11** to C**15**, the size field C**16** and I/O (Input/Output) volume field C**17** can also be managed by the management table T**10**.

[0112] The size field C**16** indicates the total capacity of the file groups stored in the respective directories of the logical directory. The I/O volume field C**17** indicates the frequency of file access by the client **60** with respect to each directory of the logical directory.

[0113] FIG. **8** is an explanatory diagram showing an example of a system constitution management table T**20**. The system constitution management table T**20** serves to manage the constitution of the file sharing system. The management table T**20** associates and manages a site name field C**21**, a node name field C**22**, an IP address field C**23**, a master ranking field C**24**, a submaster ranking field C**25**, and another field C**26**, for example.

[0114] The site name field C**21** stores information indicating either the local site **10** or remote site **20**. The node name field C**22** stores information for identifying each node **30**. The IP address field C**23** stores address information for accessing

each node **30**. The master ranking field C**24** stores the ranking of the node for the master node. Likewise, the ranking of the node which is the submaster node is stored in the submaster ranking field C**25**. The other field C**26** is able to store, for example, the processing performance of each node. The node with the youngest master ranking or submaster ranking value operates as the master node or submaster node. In cases where the master node or submaster node stops as a result of maintenance work, the next-ranked node operates as the master node or submaster node.

[0115] FIG. **9** shows the processing to define the system constitution management table T**20** and for sharing the system constitution management table T**20** with the respective nodes **30**. The respective flowchart shown hereinbelow provides an overview of the respective processing to the extent required to understand and implement the present invention and sometimes differs from the actual computer program. A so-called person skilled in the art is surely able to change and delete the illustrated steps and add steps which are not intrinsically new and so forth.

[0116] The user uses the management device **50** to set each of the values of the respective items of the C**21** to C**24** and C**26** in the master node management table T**20** (S**10**). A case where the submaster ranking is determined by the remote site **20** will be described. Further, in the following description, a node **30** in the local site **10** will sometimes be called a 'local node' and a node in the remote site **20** will sometimes be called a 'remote site'.

[0117] The master node registers the value input from the management device **50** in the system constitution management table T**20** (S**11**) and transmits the management table T**20** to the submaster node in the remote site **20** (S**13**).

[0118] Upon receipt of the management table T**20** from the master node (S**13**), the submaster node determines the submaster ranking (S**14**) and registers same in the management table T**20** (S**15**). The submaster node transmits the management table T**20** to which the submaster ranking has been added to the master node (S**16**). In addition, the submaster node holds the same management table T**20** in each remote node by transmitting the management table T**20** to each remote node (S**17**).

[0119] Upon receipt of the management table T**20** from the submaster node (S**18**), the master node transmits the management table T**20** to each local node to share the same management table T**20** with each local node (S**19**). As a result, because the same system constitution management table T**20** is passed to all the nodes in the system, the master node reports the fact that the definition of the system constitution is complete to the management device **50** (S**20**). The management device **50** confirms the fact that the definition of the system constitution is complete (S**21**). Further, the constitution may be such that the user sets the submaster ranking in S**10**. In this case, S**14**, S**15**, S**16**, and S**18** are removed from the flowchart in FIG. **9**.

[0120] FIG. **10** is a flowchart showing the processing that serves to define management table T**10** for controlling the architecture of the logical directory (GNS) and remote copies and which serves to share the management table T**10** with the respective nodes **30**.

[0121] The user uses the management device **50** to define each of the respective items C**11** to C**13** relating to the logical directory in the management table T**10** in the master node (S**30**). The master node registers a value defined by the user in the management table T**10** (S**31**). Likewise, the user uses the management device **50** to define respective remote copy-related items C**14** and C**15** in the management table T**10** in the master node (S**32**). The master node registers the value defined by the user in the management table T**10** (S**33**).

[0122] The user indicates the GNS settings (S**34**) 'GNS settings' signifies the fact that the content of the management table T**10** is reflected in all the nodes. Therefore, the master node transmits the management table T**10** to the submaster node (S**35**) Upon receipt of the management table T**10** from the master node (S**36**), the submaster node determines the copy destination node and directory number or the like (S**37**) and registers same in the management table T**10** (S**38**). Here, the submaster node is able to determine remote node and directory number for copying data from the local node on the basis of the spare capacity of the volumes **123**, the processing performance of the respective remote nodes, and the forecast load or the like when the remote node is used as the copy destination node, for example. Alternatively, the constitution may be such that the user determines the remote node associated with the local node manually.

[0123] The submaster node transmits the management table T**10** for which the addition of the copy destination node and so forth is complete to the master node (S**39**). In addition, the submaster node transmits the completed management table T**10** to the respective remote nodes and causes the same management table T**10** to be shared by the respective remote nodes (S**40**).

[0124] Upon receipt of the management table T**10** from the submaster node (S**41**), the master node transmits the management table T**10** to the respective local nodes and causes the same management table T**10** to be shared by the respective local nodes (S**42**). As a result, because the management table T**10** is distributed to all of the nodes in the system, the master node reports the fact that the setting of the management table T**10** is complete to the management device **50** (S**43**).

[0125] Upon confirmation of the setting completion (S**44**), the management device **50** indicates the start of the remote copy to the master node (S**45**). As indicated earlier, the management table T**10** also contains information related to a remote copy irrespective of information related to the architecture of the logical directory and, therefore, a remote copy can be started following completion of the management table T**10**.

[0126] The instruction to start the remote copy issued by the management device **50** is reported by the master node to the respective local nodes and remote copy processing is started at each of the local nodes and the remote nodes forming the copy pairs (S**47**).

[0127] If all the remote copies between the respective local nodes and remote nodes forming the copy pairs are complete, the data in the local site **10** and the data in the remote site **20** are synchronized for the copy target data. All of the data in the local site **10** may be copied to the remote site **20** as the copy target and the data for which a copy is not required can be excluded from the remote copy target.

[0128] Upon receipt of a report to the effect that data from the respective local nodes are synchronized (S**48**), the master node reports the fact that the synchronization of the data is complete to the management device **50** (S**49**). The management device **50** confirms that the data synchronization processing is complete (S**50**). The above synchronization processing is implemented by a remote-copy initial copy or the like, for example.

[0129] FIG. **11** is a flowchart showing normal file access processing. If the client **60** issues an update request (that is, a write access) (S**60**), the update request is received by the master node.

[0130] The master node uses the management table T**10** to specify the responsible node that is to process the update request (S**62**). The master node converts the update request from the client **60** into an update request addressed to the responsible node (S**63**) and transfers the converted update request to a responsible node (S**64**).

[0131] Upon receipt of an update request from the master node (S**65**), the responsible node (which is the local node in FIG. **11**) reports the fact that processing is possible to the client **60**. The client **60** transmits write data and attributes that are to be simultaneously updated to the responsible node (S**66**) and the responsible node receives the write data and so forth (S**67**).

[0132] The responsible node writes write data and attributes received from the client **60** to the volume **123** (S**68**) and updates a log (S**69**). This log is for managing the file access history. The responsible node reports the fact that update request processing is complete to the client **60** (S**70**).

[0133] Thereafter, the responsible node references the management table T**10** (S**72**) and specifies the node to which the write data are to be transferred (copy destination node) (S**73**). The responsible node issues a file update request to the copy destination node (S**74**). Upon receipt of the update request from the copy source node (S**75**), the copy destination node reports the fact that update request processing is possible. As a result, the copy source node transmits write data and attributes to the copy destination node (S**76**) and the copy destination node receives write data and so forth (S**77**) and writes same to the volumes **123** in the remote site **20** (S**78**).

[0134] The copy destination node (copy destination remote node) updates the log after writing write data and so forth to the volume **123** (S**79**) and reports the end of processing to the copy source node (S**80**). The copy source node confirms the fact that the remote copy is complete (S**81**).

[0135] FIG. **12** is a flowchart showing the details of the remote copy processing indicated in S**47** in FIG. **10**. The local node constituting the copy source node specifies the list of files that are preset as the copy target (S**90**). The local node references the management table T**10** (S**91**) and generates a transfer path for each file of the copy target (S**92**).

[0136] The local node uses the respective transfer paths to transmit update requests, data, and attributes to the remote node constituting the copy destination node (S**93**, S**95**). Upon receipt of the update request and data and so forth from the local node (S**94**, S**96**), the remote node writes data to the directories registered in the copy destination entity position field C**15** in the management table T**10** and reports the end of processing to the local node (S**98**).

[0137] Upon receipt of the processing end report from the remote node, the local node updates a synchronization state management table T**30** (S**99**). The synchronization state management table T**30** is a table for managing the progressive state of the initial copy.

[0138] The synchronization state management table T**30** associates and manages, for example, a field C**31** indicating the directory name of the logical directory, a field C**32** indicating the position in which the data of the directory are actually stored, a field C**33** indicating the files included in the directory, a field C**34** indicating the path for transferring the files; and a field C**35** indicating whether file synchronization is complete. By managing whether synchronization is complete for each file of the copy target, remote copy processing can be run in parallel while processing a file access request from client **60**.

[0139] FIG. **13** is a flowchart showing disaster recovery processing. A case where the local site **10** has stopped due to a disaster or the like is assumed. Because a response to the effect that processing is possible is sent back from the local node even when the client **60** issues an update request to the local node (S**100**), the client **60** awaits processing (S**101**).

[0140] A user who is anxious about stoppage of the local site **10** issues a clear instruction for a failover to the submaster node from the management device **50** (S**102**). Upon receipt of this instruction (S**103**), the submaster node reproduces the logical directory at the remote site **20** by treating the copy destination node field C**14** of the management table T**10** as the 'responsible node field C**12**' and the entity position field C**15** as the entity position field C**13** (S**104**) and reports the fact that the logical directory is reproduced to the management device **50** (S**105**). Upon confirming reproduction of the logical directory (S**106**), the management device **50** instructs the switching of the access destination to the client **60** (S**107**). As a result, client **60** switches the access destination from the local site **10** to the remote site **20** (S**108**).

[0141] If the client **60** issues an update request to the remote site **20** (S**109**), the submaster node specifies the responsible node that is to process the update request and converts the update request into an update request that is addressed to the responsible node (S**110**). Upon receipt of the converted update request (S**111**), the responsible node reports the fact that processing is possible to the client **60**. As a result, the client **60** transmits the write data and attributes to the responsible node (S**112**).

[0142] Upon receipt of the write data and attributes from the client **60** (S**113**), the responsible node reports the fact that the update processing is complete to the client **60** (S**114**). As a result of this report, the client **60** confirms the fact that the update processing is complete (S**115**). The responsible node writes the write data and attributes received from the client **60** to the volume **123** and updates the log (S**117**).

[0143] This embodiment which is so constituted affords the following effects. According to this embodiment, by performing a remote copy between the local site **10** and remote site **20**, the data between the two sites **10** and **20** are synchronized and, in cases where a fault occurs at the local site **10**, the logical directory can be reproduced in the remote site **20**. Therefore, a logical directory **8** with an improved fault tolerance can be provided even in cases where the constitutions of the physical resources differ between the respective sites **10** and **20**.

[0144] In this embodiment, by using the management table T**10** that integrates the GNS management information and copy management information and treating part of the copy management information as part of the GNS management information, the logical directory can be reproduced relatively rapidly in the remote site **20**.

[0145] In other words, in this embodiment, by integrating management information for constructing the logical directory and management information for performing a remote copy, the remote copy management information can be used for the reproduction of the logical directory. Hence, in this embodiment, there is no need to especially prepare information for re-constructing the logical directory at the remote site **20**, the memory resources of the respective nodes **30** can be

utilized effectively, and the logical directory can be re-constructed using relatively simple control. As a result, the fault tolerance of the file sharing system improves and user convenience improves.

Second Embodiment

[0146] A second embodiment of the present invention will now be described on the basis of FIGS. **14** to **23**. The respective embodiments that appear hereinbelow correspond to modified examples of the first embodiment. In this embodiment, data synchronization between the local site **10** and remote site **20** is implemented by means of a remote copy between the storage devices **100**. Descriptions that duplicate those for the first embodiment will be omitted hereinbelow and the description will focus on the parts that differ from those of the first embodiment.

[0147] FIG. **14** is an explanatory diagram of the overall constitution of the file sharing system according to this embodiment. The storage device **100** in the local site **10** and the storage device **100** in the remote site **20** are connected via an inter-site communication network CN**4** which constitutes the 'second communication path'.

[0148] FIG. **15** is an explanatory diagram showing the detailed constitution within one site. If we focus on the storage device **100** in this embodiment, the CHA**111** shown on the middle right of FIG. **15** is connected to the storage device **100** in another site via the communication network CN**4**. In this embodiment, a block-unit remote copy is performed to synchronize the data asynchronously with respect to the processing of the file access request that is executed by the NAS node **30**.

[0149] FIG. **16** is an explanatory diagram that shows an aspect of a copy pair for performing a block-unit remote copy between volumes (between logical devices). The logical device (copy source logical device) **122** that corresponds to the respective copy source volumes **123** in the local site **10** forms a copy pair with the logical device (copy destination logical device) **122** that corresponds with the respective copy destination volumes in the remote site **20**.

[0150] FIG. **17** indicates an inter-storage copy management table T**40** that is used to perform a remote copy between storage devices **100**. This copy management table T**40** can be stored in the shared memory **113** or cache memory **114** of the storage device **100**, for example. The copy management table T**40** is held by both the storage device **100** in the local site **10** and the storage device **100** in the remote site **20**.

[0151] The management table T**40** comprises, for example, a copy source logical device field C**41**, a copy destination logical device field C**42**, and a copy state field C**43**. The copy source logical device and copy destination logical device are each specified by means of a combination of the device number identifying the respective storage devices **100** ('SS#' in Figs.) and the logical device number for identifying the respective logical devices **122** ('LU#' in Figs.) in C**41** and C**42**. Information indicating a state reflecting whether synchronization is in progress is set in C**43**.

[0152] As shown in the lower part of FIG. **17**, an update request can also be managed by means of a differential bitmap T**41** during a remote copy or after a remote copy is complete. For example, by recording the position of the update request that occurs after the end of the initial copy in the differential bitmap T**41**, only the differential data can be transferred in cases where the copy source logical device and the copy destination logical device are re-synchronized.

[0153] Further, as shown in the lower part of FIG. **17**, identification information for identifying the copy source logical device (ID) can be stored in an area for storing management information in the copy destination logical device. This ID is constituted by combining the device number (SS#) of the storage device **100** in which the copy source logical device is provided and the device number (LU#) of the copy source logical device, for example.

[0154] FIG. **18** shows a management table T**10**A for GNS and remote copies which is used in this embodiment. In this embodiment, the entity positions C**13**A and C**15**A are provided in addition to each of the items described in the management table T**10**. The device number of the storage device **100** and the device number of the logical device are set as the entity positions C**13**A and C**15**A.

[0155] FIG. **19** shows the processing for setting the management table T**10**A. In S**30**A and S**32**A, the generation of a logical directory and remote copy-related settings are input to the management table T**10**A from the management device **50**. In S**37**A, which is executed by the submaster, the positions of copy destinations nodes and entities are added to the management table T**10**. The management device **50** issues an instruction to start the remote copy to the storage device **100** in the local site **10** with predetermined timing (S**120**). In the following description, the storage device **100** in the local site **10** is sometimes referred to as the local storage device and the storage device **100** in the remote site **20** is sometimes called the remote storage device.

[0156] FIG. **20** is a flowchart showing the block-unit remote copy processing that is executed between the storage devices **100**. The remote copy processing is executed asynchronously with respect to the file access request processing of the NAS nodes **30**.

[0157] Steps appearing in FIG. **19** are included in FIG. **20** for the sake of understanding. The management device **50** makes remote copy-related settings with respect to the local storage device (S**121**). The local storage device registers the values input from the management device **50** in the inter-storage copy management table T**40** (S**122**).

[0158] The management device **50** issues an instruction to start a remote copy (S**123**) and, when the local storage device receives this instruction (S**124**), the local storage device starts a remote copy on the basis of the content of the copy management table T**40**. In other words, data are transmitted in block units from the copy source logical device to the copy destination logical device (S**125**). The remote storage device stores block data that are received from the local storage device in the copy destination logical device (S**126**).

[0159] If a data copy from the copy source logical device to the copy destination logical device is complete, the local storage device reports the fact that the synchronization of data is complete to the management device **50** (S**127**) and the management device **50** confirms the fact that the synchronization of data is complete (S**128**).

[0160] FIG. **21** is a flowchart showing an example of the steps to determine the copy destination node indicated in S**37**A in FIG. **19**. This processing is executed for each directory corresponding to the node name of the respective logical directories (S**130**).

[0161] The submaster node specifies the copy source logical device that corresponds to the processing-target directory by using the management table T**10**A (S**131**). The submaster node finds a copy destination logical device that stores the ID of the copy source logical device by searching the manage-

ment information storage area of the respective logical devices **122** in the remote storage device (S**132**).

[0162] The submaster node detects the remote node that is able to access the copy destination logical device thus found (S**133**) and selects one copy destination node from among the detected remote nodes in accordance with the expected load and so forth (S**134**). The submaster node registers the selected copy destination node in the management table T**10**A (S**135**). The submaster node registers the 'entity position' and directory number for accessing the copy destination logical device found via the selected copy destination node in the management table T**10**A (S**135**).

[0163] FIG. **22** shows the processing to transmit the differential data generated following completion of the data synchronization between the storage devices **100** from the local storage device to the remote storage device. The local node processes a file access request from the client **60** basically extraneously from the operation of the storage device **100**. As a result, a difference arises between the data stored in the local storage device and the data stored in the remote storage device. This difference is managed by the differential bitmap T**41**.

[0164] Upon detection of the occurrence of differential data (S**140**), the local storage device transmits the differential data to the remote storage device (S**141**). The remote storage device receives the differential data (S**142**) and stores same in the copy destination logical device (S**143**). As a result of a report from the remote storage device (S**144**), the local storage device confirms that the differential data have been written to the copy destination logical device (S**145**).

[0165] For the sake of convenience, S**141** and subsequent steps were described as being executed once the differential data have been generated in S**140**. However, the start of the execution of these steps is not limited to such a condition. The start of differential data copying may also be triggered when a predetermined amount of differential data has been accumulated or when a predetermined time has elapsed since the transfer of the previous differential data, for example.

[0166] FIG. **23** is a flowchart showing the disaster recovery processing. Upon receipt of a failover start instruction from the management device **50** (S**103**), the submaster node issues an instruction to start the failover to the remote storage device (S**150**). The remote storage device executes the processing required for the failover (S**151**). As the processing required for the failover, processing to establish a readable/writable state by rewriting the access control information set for the copy destination logical device can be cited by way of example.

[0167] The submaster node issues an instruction to start the failover to the respective remote nodes (S**152**) and mounts the volume corresponding to the copy destination logical device on the remote node (S**153**). Here, the respective remote nodes perform fail system ('FS' in FIG. **23**) matching prior to mounting the volume. A command for checking the fail system such as a a fsck command, for example, is used in the fail system matching.

[0168] This embodiment so constituted affords the same effects as those of the first embodiment. In addition, because a block-unit remote copy is performed between the storage devices **100** in this embodiment, the load on the respective NAS nodes **30** constituting the copy source or copy destination can be alleviated, whereby the response performance of the file sharing system can be increased.

Third Embodiment

[0169] A third embodiment will now be described based on FIGS. **24** and **25**. In this embodiment, a correspondence method in a case where the constitution of the local site **10** is changed will be described. As shown in FIG. **24**, a case where a new directory '/e' is added to the logical directory and where a new local node **30** (E) which corresponds with the new directory is added to the local site **10** is given by way of example. The file group managed by the newly added local node **30** (E) is copied to the remote node **30** (G) in the remote site **20**.

[0170] FIG. **25** is a flowchart showing processing that serves to reflect changes to the constitution in the local site **10** in the management table T**10** in the respective nodes **30**. This processing can be carried out by utilizing processing to hold the management table T**10** in all of the nodes. The management device **50** defines the respective GNS-related items of the changed part (S**30**B) and the master node records same in the changed (added) record (S**31**). Likewise, the management device **50** defines the respective remote copy-related items of the changed part (S**32**B) and the master node adds same to the changed (added) record (S**33**).

[0171] The master node transmits a changed part record in the management table T**10** to the submaster node (S**35**B). Upon receipt of the changed part record (S**36**B), the submaster node determines a copy destination node or the like that corresponds to the changed part and adds same to the record (S**37**, S**38**) and transmits the changed part record to the master node (S**39**B).

[0172] Thus, in this embodiment, in cases where the constitution of the local site **10** is changed, the content of the management table T**10** held in each node **30** can be updated simply by reporting only the record for parts related to the change to the respective nodes **30**. Further, although a description is omitted, only the record for the changed part need be transmitted to the respective nodes **30** of the system constitution management table T**20** as above.

Fourth Embodiment

[0173] A fourth embodiment will be described based on FIGS. **26** and **27**. In this embodiment, a correspondence method for a case where the constitution of the remote site **20** is changed will be described. A case where a new NAS node **30** (H) is added to the remote site **20** and a volume (VOL **13**) for which the node **30** (G) has been responsible thus far is moved to the node **30** (H) as shown in the lower part of FIG. **26**.

[0174] Further, at the remote site, the volume (Vol **13**) for which node **30** (G) is responsible can be pre-constituted by a plurality of logical devices. In cases where this volume (Vol **13**) is constituted by a plurality of logical devices, some of the logical devices are able to move from the node **30** (G) to node **30** (H).

[0175] Alternatively, yet another logical device is prepared and this new logical device is temporarily allocated to node **30** (G) to move the directory data of the volume (Vol **13**) to the new logical device. Further, a method where the new logical device, to which the directory data have been moved, is reallocated to node **30** (H) is also possible.

[0176] FIG. **27** is a flowchart showing the processing to reflect a change to the constitution of the remote site in the management table T**10** in each node **30**. If a definition is input from the management device **50** for the changed (added) constitution (S**160**), the submaster node registers the definition related to the changed (added) constitution in the management table T**10** (S**161**) and transmits only the changed part record to the master node **30** (S**162**).

[0177] Upon receipt of the changed part record (S**163**), the master node registers the changed part record in the management table T**10** (S**164**) and reports the completion of settings to the submaster node (S**165**). In addition, the master node transmits the changed part record to each local node to update the management table T**10** of the respective local nodes (S**166**).

[0178] Upon receipt of the setting completion report from the master node (S**167**), the submaster node transmits a changed part record to the respective remote nodes to update the management table T**10** in the respective remote nodes (S**168**). Upon receipt of the setting completion report from the submaster node (S**169**), the management device **50** confirms that fact that the change to the remote site constitution has been transmitted to each node (S**170**).

[0179] Thus, according to this embodiment, so too in the case where the constitution of the remote site **20** is changed, as per the third embodiment, the content of the management table T**10** held in each node **30** can be updated simply by reporting only the record of the change-related part to each node **30**.

[0180] Further, the present invention is not limited to or by the above embodiments. A person skilled in the art is able to perform a variety of additions and modifications within the scope of the present invention.

What is claimed is:

1. A file sharing system having a first site and a second site, wherein

a plurality of first file sharing devices in the first site and a plurality of second file sharing devices in the second site are connected to enable mutual communication via a first communication path capable of data communication in file units,

the system comprising:

a logical directory supply section which, by using first management information for managing associated relationship between a single logical directory structure that is generated across the respective first file sharing devices and a first directory structure that the respective first file sharing devices comprise, supplies the logical directory structure that is formed by virtually integrating the respective first directory structures to a client device;

a copy control section which, by using second management information for managing associated relationship between storage positions of data managed by the respective first file sharing devices and storage positions of data managed by the respective second file sharing devices, transmits and copies copy target data among the data stored in the respective first file sharing devices to second file sharing devices that are associated with the respective first file sharing devices; and

a reproduction section which reproduces the logical directory structure that is formed by virtually integrating the respective second directory structure by using the first management information and the second management information in cases where a fault occurs at the first site.

2. The file sharing system according to claim **1**, wherein the structure of the volume used by the respective first file sharing devices to input and output data and the structure of the volume used by the respective second file sharing devices to input and output data are different.

3. The file sharing system according to claim **1**, wherein

the first management information includes respective directory names of the logical directory structures, responsibility information for specifying predetermined first file sharing devices that are responsible for the respective directory names; and first storage position information for indicating the storage position of the data managed by the predetermined respective first file sharing devices; and

the second management information includes the first storage position information, second storage position information for indicating the storage position of data managed by the respective second file sharing devices, and copy destination device information for specifying second file sharing devices that are associated with the predetermined first file sharing devices.

4. The file sharing system according to claim **1**, wherein

the first management information and the second management information are stored in a common management table;

the management table is constituted comprising respective directory names of the logical directory structures, responsibility information for specifying predetermined first file sharing devices that are each responsible for the respective directory names, first storage position information indicating the storage position of data managed by the respective predetermined first file sharing devices, copy destination device information for specifying predetermined second file sharing devices that each correspond with the respective predetermined first file sharing devices, and second storage position information indicating the storage positions of data managed by the respective second file sharing devices, and wherein

the reproduction section reproduces the logical directory structures by treating the copy destination device information as the responsibility information in cases where a fault has occurred.

5. The file sharing system according to claim **1**, wherein the copy control section transmits and copies the copy target data from the first file sharing devices to the second file sharing devices via the first communication path.

6. The file sharing system according to claim **1**, wherein

the respective first file sharing devices store and manage data in a first volume provided by a first storage device in the first site;

the respective second file sharing devices store and manage data in a second volume provided by a second storage device in the second site;

the first storage device and the second storage device are connected to enable mutual communication via a second communication path that is capable of data communication in block units; and

the copy control section transfers and copies the copy target data from the first volume to the second volume via the second communication path.

7. The file sharing system according to claim 6, wherein
the second volume stores copy source volume identification information for identifying the first volume associated as the copy source with the second volume; and
the reproduction section reproduces the logical directory structure that is formed by virtually integrating the respective second directory structure by using the copy source volume identification information, the first management information, and the second management information.

8. The file sharing system according to claim 1, wherein
the respective first file sharing devices and the respective second file sharing devices hold the first management information and the second management information, and
in cases where either the first site or the second site undergoes a change to the logical directory structure or a copy-related structure, differential information related to the structural change is reported to the respective first file sharing devices and the respective second file sharing devices, and the differential information is reflected in the first management information or the second management information held by the respective first file sharing devices and the respective second file sharing devices.

9. A method of generating a single logical directory structure by using a file sharing system, the file sharing system having a first site having a plurality of first file sharing devices, a second site having a plurality of second file sharing devices, and a first communication path that is connected such that the respective first file sharing devices and the respective second file sharing devices are able to perform data communication in file units,
the method comprising the steps of:
setting first management information for managing associated relationship between a single logical directory structure which is generated across the respective first file sharing devices and a first directory structure that the respective first file sharing devices comprise;
providing a client device with a logical directory structure that is made by using the first management information to virtually integrate the respective first directory structures;
setting second management information for managing associated relationship between storage positions of data managed by the respective first file sharing devices and storage positions of data managed by the respective second file sharing devices;
transmitting and copying copy target data among the data that are stored in the respective first file sharing devices to second file sharing devices that are associated with the respective first file sharing devices by using the second management information;
detecting whether a fault has occurred in the first site; and
reproducing the logical directory structure that is formed by virtually integrating the respective second directory structure by using the first management information and the second management information in cases where the occurrence of a fault is detected.

10. A file sharing system having a first site and a second site, wherein
(1) the first site comprises:
(1-1) a plurality of first file sharing devices each having a first directory structure;
(1-2) a first storage device which is connected via a first intra-site communication network to the respective first file sharing devices, and which supplies a first volume to the first file sharing devices respectively; and
(1-3) a master device that issues a predetermined report to the first file sharing devices respectively; and
(2) the second site comprises:
(2-1) a plurality of second file sharing devices each having a second directory structure and being provided in a number that differs from the number of first file sharing devices;
(2-2) a second storage device which is connected via a second intra-site communication network to the respective second file sharing devices and which supplies a second volume to the second file sharing devices respectively; and
(2-3) a submaster device that issues a predetermined report to the second file sharing devices respectively;
(3) the respective first file sharing devices and the respective second file sharing devices are connected via a first communication path that is capable of data communication in file units, and the first storage device and the second storage device are connected via a second communication path that is capable of data communication in block units;
(4) the respective first file sharing devices, the respective second file sharing devices, the master device, and the submaster device each hold a management table, and the management table is constituted comprising respective directory names that correspond to respective node names of the logical directory structure, responsibility information for specifying predetermined first file sharing devices responsible for each of the directory names, first storage position information indicating storage positions of data managed by the respective predetermined first file sharing devices, copy destination device information for specifying predetermined second file sharing devices each corresponding to the respective predetermined first file sharing devices, and second storage position information indicating storage positions of data managed by the respective predetermined second file sharing devices;
(5) the master device generates a single logical directory structure that is generated across the respective first file sharing devices by using the management table and supplies the single logical directory structure to a client device;
(6) the respective first file sharing devices transmit data that are stored in the first volume to the respective second file sharing devices via the first communication path by using the management table and store the data in the second volume; and
(7) the submaster device reproduces the logical directory structure by means of a second directory structure that the respective second file sharing devices comprise by treating the copy destination device information in the management table as the responsibility information in cases where execution of a failover is instructed.

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