(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 September 2010 (02.09.2010)

PCT

(10) International Publication Number
WO 2010/097962 A1

(51) International Patent Classification:
G06F 11/20 (2006.01) *G06F 11/14* (2006.01)

(21) International Application Number:
PCT/JP2009/054219

(22) International Filing Date:
25 February 2009 (25.02.2009)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR),

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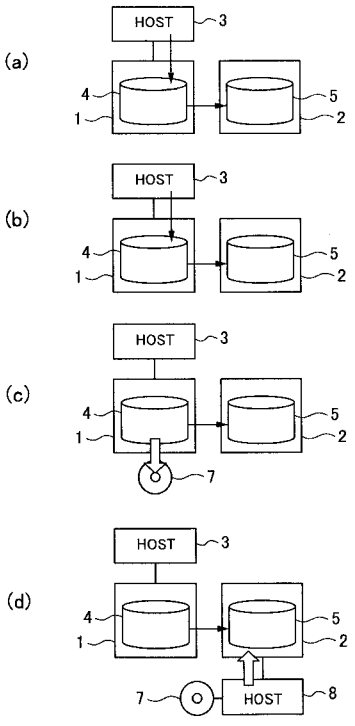
(54) Title: STORAGE SYSTEM AND ITS INITIAL COPY METHOD

FIG.1



(57) Abstract: Upon starting the initial copy process, a pair creation command is issued from a primary disk subsystem to a secondary disk subsystem. The secondary disk subsystem sets a target area of a second disk drive to an unwritten status, and thereafter writes update data that was updated in a primary site into a designated area of the second disk drive. Subsequently, when data of a first disk drive is backed up to an external medium, the external memory medium is transported to a secondary site, and then connected to a host computer. Unwritten data among the backup data recorded in the external memory medium is thereafter restored to the first disk drive, and the initial copy is completed on the condition that all data in the first disk drive has been copied to the second disk drive.

WO 2010/097962 A1

OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

DESCRIPTION

STORAGE SYSTEM AND ITS INITIAL COPY METHOD

TECHNICAL FIELD

The present invention relates to technology of recording data of a logical device in a memory apparatus installed at a primary site to a logical device in a memory apparatus installed at a secondary site in order to achieve the redundancy of such data.

BACKGROUND ART

In recent years, in order to prevent the loss of data stored in a memory apparatus in the event of a failure or a disaster, measures are being taken to achieve the redundancy of data, for instance, by connecting a plurality of physically-separated sites with a communication line, sending data of a primary logical device in a primary memory apparatus installed at a primary site to a secondary memory apparatus installed at a remote secondary site via a communication line, and recording such data in the secondary logical device of the secondary memory apparatus at the secondary site.

Remote copy is known as backup technology for achieving the redundancy of data. Remote copy is a technique of setting copy-target volumes in a primary memory apparatus as the copy source and a secondary memory apparatus as the copy destination, and copying data from the primary logical device to the secondary logical device so that data of the primary logical device in the primary memory apparatus and data of the secondary logical device in the secondary memory apparatus will mutually coincide.

By using the remote copy technique, with corporations, for instance, it will be

possible to consolidate, in real time, data of memory apparatuses of the respective sites in the memory apparatuses within the data center. Incidentally, the pair configured from a primary logical device and a secondary logical device is referred to as a remote copy pair. In order to create a remote copy pair, it is necessary to copy all data of the primary logical device to the secondary logical device. This copy process is referred to as an initial copy.

Normally, the initial copy is performed with a method of transferring remote copy target data in the primary memory apparatus via a network connecting the primary memory apparatus and the secondary memory apparatus. However, with this method, since vast amounts of data are transferred via the communication network connecting the primary memory apparatus and the secondary memory apparatus during the initial copy, it is necessary to prepare a broadband communication network even in a low-load I/O (Input/Output) processing environment, and this led to a wasteful business investment.

Moreover, for users under a contract of paying a traffic charge for the communication network (communication line) connecting the primary memory apparatus and the secondary memory apparatus, this will lead to a wasteful investment since users must pay a fee in accordance with the data traffic required for the initial copy.

In light of the above, a method has been proposed to reduce the data traffic between sites as much as possible during the initial copy. Specifically, with this method, a snapshot is created between a copy source logical device and an intermediate logical device in a memory apparatus at a first site (primary site), the pair status of the snapshot is thereafter separated, a logical device corresponding to the intermediate logical device is subsequently formed in an external memory apparatus (portable memory medium), the external memory apparatus is transported to a second site (secondary site) using a transportation means, the logical device formed in the external memory apparatus is registered in the memory apparatus at the second site, and only

differential information that differs from the logical device formed in the external memory apparatus is thereafter copied from the memory apparatus at the first site to the memory apparatus at the second site via a global network (refer to Patent Document 1).

[Related Art Document]

[Patent Document 1]

Japanese Patent Laid-Open Publication No. 2006-338250

DISCLOSURE OF THE INVENTION

In the future, it is possible that needs of an initial copy solution capable of reducing the data traffic among a plurality of sites will increase. Nevertheless, with the method described in Patent Document 1, in order to recognize the logical device of the external memory apparatus, it is necessary to set an intermediate logical device as the virtual logical device, and once copy the copy target data of the logical device (copy source logical device) in the memory apparatus to the intermediate logical device. In addition, it is also necessary to subsequently perform the operation of separating the copy source logical device and the intermediate logical device in order to prevent the copy target data of the intermediate logical device from becoming updated. Thus, the method described in Patent Document 1 is unable to sufficiently shorten the time required for performing the initial copy.

The present invention was devised in view of the problems encountered in the conventional technology described above. Thus, an object of the present invention is to provide a storage system and its initial copy method capable of reducing the processing required for the initial copy.

In order to achieve the foregoing object, the present invention is characterized in that a primary site issues a pair creation command to a secondary site prior to

copying data of a primary volume of the primary site to a secondary volume of the secondary site, commands the copying of data that was updated after the pair creation command was issued, and responds to a backup request and outputs data of the primary volume as backup data to the backup requestor. Meanwhile, the secondary site responds to the pair creation command from the primary site and sets the entire initial copy target area of the secondary volume to an unwritten status, thereafter writes the update data updated at the primary site as differential information into the secondary volume, and, if data from an external memory medium is input, copies only unwritten data among such data to the secondary volume, and thereafter completes the initial copy on the condition that all differential information is copied to the secondary volume; that is, on the condition that there is no remaining unwritten data.

According to the present invention, it is possible to reduce the processing required for the initial copy.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A to Fig. 1D are conceptual diagrams explaining the operational procedure of the storage system according to the present invention;

Fig. 2 is a diagram explaining the status of a secondary volume during pair creation;

Fig. 3 is a diagram explaining the status upon writing data from a primary site into a secondary volume after the pair creation;

Fig. 4 is a diagram explaining the status upon restoring data of an external memory medium to a secondary volume;

Fig. 5 is a block configuration diagram of the storage system showing an embodiment of the present invention;

Fig. 6 is a configuration diagram of a pair information management table;

Fig. 7 is a configuration diagram of a primary/secondary communication parameter table;

Fig. 8 is a diagram showing a display example of a pair creation screen;

Fig. 9 is a diagram showing a display example of a pair creation command line;

Fig. 10 is a flowchart explaining the processing of the primary site during pair creation;

Fig. 11 is a flowchart explaining the processing of the secondary site during pair creation;

Fig. 12 is a flowchart explaining the remote I/O processing at the secondary site;

Fig. 13 is a diagram showing an example of a display screen upon switching to the restoration mode;

Fig. 14 is a flowchart explaining the restoration mode ON processing;

Fig. 15 is a flowchart explaining the restoration processing; and

Fig. 16 is a flowchart explaining the restoration mode OFF processing.

BEST MODE FOR CARRYING OUT THE INVENTION

Embodiments of the present invention are now explained with reference to the attached drawings. Fig. 1A to 1D are conceptual diagrams explaining the operational procedure of a storage system according to the present invention. Fig. 1A shows a storage system comprising a primary site 1 including a disk array device, and a secondary site 2 including another disk array device. The primary site 1 is used for storing a data group to be used by a host computer 3 in a primary volume 4. The secondary site 2 is used as a backup of the primary site 1, and is used for storing a data group of the primary volume 4 in a secondary volume 5.

The host computer 3 functions as a server, and is able to access the primary

site 1 and the secondary site 2, respectively. The primary site 1 and the secondary site 2 are connected via a communication network (not shown).

Here, the present invention causes the host computer 3 to issue a pair creation command to the primary site 1 prior to copying data of the primary volume 4 to the secondary volume 5. In response to the pair creation command from the host computer 3, the primary site 1 issues a pair creation command to the secondary site 2. When the secondary site 2 inputs the pair creation command from the primary site 1, as shown in Fig. 2, it sets bits of the entire area of bitmap information 6 provided in units of I/O (Input/Output) processing for each secondary volume 5 to an unwritten status; for instance, it sets each bit to an ON state.

Subsequently, as shown in Fig. 1B, if update I/O processing is input from the host computer 3 after sending the pair creation command to the secondary site 2, the primary site 1 sends the update data that was updated pursuant to the update I/O processing to the secondary site 2.

In the foregoing case, as shown in Fig. 3, the secondary site 2 respectively writes, as a copy mode, the update data 5a, 5b sent from the primary site 1 into a designated area of the secondary volume 5. Here, the secondary site 2 sets the bits corresponding to write locations 6a, 6b of the update data 5a, 5b among the bitmap information 6 to a written status, or an OFF state.

Subsequently, as shown in Fig. 1C, when a backup request is sent from the host computer 3 to the primary site 1, the primary site 1 backs up data of the primary volume 4 to an external medium (portable memory medium) 7. In the foregoing case, it is also possible to send data of the primary volume 4 as backup data to the host computer 3, and cause the host computer 3 to back up data of the primary volume 4 to the external medium 7. A transportation means such as a vehicle is used to thereafter transport the external memory medium 7 to the secondary site 2.

Subsequently, as shown in Fig. 1D, when a command for restoring data is input

to the secondary site 2 from a host computer 8 or a maintenance terminal (not shown) managing that secondary site 2, the secondary site 2 restores the data recorded in the external memory medium 7 to the secondary volume 5. Here, the secondary site 2 switches the mode from a copy mode to a restoration mode, and writes the data of the external memory medium 7 into the secondary volume 5.

In the foregoing case, as shown in Fig. 4, the secondary site 2 copies only the bits of the unwritten areas 6c, 6d, 6e, 6f, 6g among the bitmap information 6 according to the update data 5c, 5d, 5e, 5f, 5g as the write processing in the restoration mode.

Subsequently, after the writing of data is complete, the secondary site 2 sets the bits among the bitmap information 6 to which the update data has been copied to a written status

Subsequently, the secondary site 2 cancels the restoration mode. On the condition that all bits of the bitmap information 6 have been written, the primary site 1 and the secondary site 2 mutually become a pair status.

Consequently, the initial copy of copying data of the primary volume 4 to the secondary volume 5 is complete. Here, remote copy can be implemented without having to suspend the primary site 1 and the secondary site 2.

[Embodiments]

An embodiment of the present invention is now explained with reference to the attached drawings. Fig. 5 is a block configuration diagram of a storage system showing an embodiment of the present invention. In Fig. 1, the primary site 1 and the secondary site 2 configuring the storage system are respectively provided with a primary disk subsystem 10 and a secondary disk subsystem 12. The primary disk subsystem 10 comprises a primary disk array device 14 as a storage controller, and the secondary disk subsystem 12 comprises a secondary disk array device 16 as a storage controller.

The primary disk array device 14 is connected to a primary site host computer

20 via a communication network 18, connected to a maintenance terminal 24 via a communication network 22, connected to a secondary disk array device 16 via a communication network (primary site/secondary site interface cable) 26, and connected to a primary disk drive 30 via a communication network 28.

The secondary disk array device 16 is connected to a secondary site host computer 34 via a communication network 32, connected to a maintenance terminal 38 via a communication network 36, and connected to a secondary disk drive 42 via a communication network 40.

The communication networks 18, 22, 26, 28, 32, 36, 40 are configured from a communication medium such as a LAN (Local Area Network), SAN (Storage Area Network), Internet or dedicated line.

If LAN is used as the communication network, the data transfer between the host computer 20 and the primary disk array device 14 and between the host computer 34 and the secondary disk array device 16 is performed via TCP/IP. If SAN is used as the communication network, the data transfer between the host computers 20, 34 and the respective disk array devices 14, 16 is performed according to a fibre channel protocol. Incidentally, the host computers 20, 34 are configured to be connectable to an external memory medium 44. The external memory medium 44 is configured portably as a portable memory medium such as a semiconductor memory or a tape.

The host computers 20, 34 are realized, for instance, with a server, personal computer, workstation, mainframe system, open system or the like. For example, if the host computers 20, 34 are connected to a plurality of client terminals via another communication network (none of these are shown), the host computers 20, 34 are able to provide services to the respective client terminals by reading and writing data from and into the respective disk array devices 14, 16 according to the request from the respective client terminals.

The primary disk array device 14 comprises a plurality of channel ports 50, a

plurality of channel adapters (primary channel adapters) 52, a plurality of cache memories 54, a plurality of shared memories 56, a switch unit 58, and a plurality of disk adapters (primary disk adapters) 60.

Each channel adapter 52 is connected to the communication networks 18, 22, 26 via each channel port 50, and each disk adapter 60 is connected to the communication network 28. In addition, each channel adapter 52, each cache memory 54 and each shared memory 56, and each disk adapter 60 are mutually connected via the switch unit 58.

Each channel adapter 52 and each disk adapter 60 comprise, for example, a print substrate mounted with a microprocessor, a memory and the like, and a control program stored in the memory, and are able to realize prescribed functions through coordination of the foregoing hardware and software.

For instance, the channel adapter 52 connected to the host computer 20 is used for controlling the transfer of data between the host computer 20 and the primary disk array device 14, and is configured from an open channel adapter or a mainframe channel adapter.

The channel adapter 52 connected to the host computer 20 receives from the host computer 20 commands for reading and writing data as well as the target data, and operates according to the received command and data. Here, when the channel adapter 52 receives a read command from the host computer 20, it stores the read command in the shared memory 56.

At this time, the disk adapter 60 is constantly referring to the shared memory 56, and, if any unprocessed read command exists in the shared memory 56, the disk adapter 60 reads designated data from the disk drive 30 according to the read command and stores such data in the cache memory 54. The channel adapter 52 thereafter reads the data stored in the cache memory 54 and sends the read data to the host computer 20.

If the channel adapter 52 receives a write command from the host computer 20, it stores the write command in the shared memory 56. After the channel adapter 52 stores the data in the cache memory 54, it sends a write completion report to the host computer 20. At this time, the disk adapter 60 reads the data stored in the cache memory 54 according to the write command stored in the shared memory 56, and stores the read data in a designated storage area of the disk drive 30.

Each disk adapter 60 controls the data communication with the disk drive 30 and constantly monitors the status of the disk drive 30, and sends the monitoring result to the maintenance terminal 24 via an internal network (not shown).

The cache memory 54 is used for storing user data and the like, and is configured, for instance, from a nonvolatile memory.

The shared memory (or control memory) 56 is configured, for instance, from a nonvolatile memory. The shared memory 56 stores, for example, control information, management information, a pair information management table and a primary/secondary communication parameter table.

The switch unit 58 is used for mutually connecting the respective channel adapters 52, the respective cache memories 54, the respective shared memories 56, and the respective disk adapters 60, and is configured, for example, from an ultrafast crossbar switch. Consequently, all channel adapters 52 and disk adapters 60 are able to respectively access each cache memory 54 and each shared memory 56 via the switch unit 58.

The disk drive 30 is configured, as a memory apparatus, from a physical storage device such as a hard disk drive (HDD), a semiconductor memory, or an optical disk. The disk drive 30 may be configured from a plurality of disk drives, and a RAID (Redundant Array of Inexpensive Disks) group as a virtual logical area may be created on a physical storage area provided by the respective disk drives 30. One or more virtual logical devices (LU: Logical Units) may be set in the RAID group. Here, the disk

drive 30 functions as a primary logical device or a primary volume (primary data volume).

The secondary disk array device 16 comprises a plurality of channel ports 70, a plurality of channel adapters (secondary channel adapters) 72, a plurality of cache memories 74, a plurality of shared memories 76, a switch unit 78, and a plurality of disk adapters (secondary disk adapters) 80.

Each channel adapter 72 is connected to the communication networks 26, 32, 36 via each channel port 70, and each disk adapter 80 is connected to the communication network 40. Moreover, each channel adapter 72, each cache memory 74 and each shared memory 76, and each disk adapter 80 are mutually connected via the switch unit 78.

Each channel adapter 72 and each disk adapter 80 comprise, for example, a print substrate mounted with a microprocessor, a memory and the like, and a control program stored in the memory, and are able to realize prescribed functions through coordination of the foregoing hardware and software.

For instance, the channel adapter 72 connected to the host computer 34 is used for controlling the data transfer between the host computer 34 and the secondary disk array device 16, and is configured as an open channel adapter or a mainframe channel adapter.

Moreover, the channel adapter 72 connected to the channel adapter 52 of the primary site 1 receives from the channel adapter 52 commands and data for pair creation via the communication network 26, and operates according to the received command and data. Here, when the channel adapter 72 receives a read command from the channel adapter 52, it stores the read command in the shared memory 76.

At this time, the disk adapter 80 is constantly referring to the shared memory 76, and, if any unprocessed read command exists in the shared memory 76, the disk adapter 80 reads designated data from the disk drive 42 according to the read

command and stores such data in the cache memory 74. The channel adapter 72 thereafter reads the data stored in the cache memory 74 and sends the read data to the channel adapter 52.

If the channel adapter 72 receives a write command from the channel adapter 52, it stores the write command in the shared memory 76. After the channel adapter 72 stores the data in the cache memory 74, it sends a write completion report to the channel adapter 52. At this time, the disk adapter 80 reads the data stored in the cache memory 74 according to the write command stored in the shared memory 76, and stores the read data in a designated storage area of the disk drive 42.

Each disk adapter 80 controls the data communication with the disk drive 42 and constantly monitors the status of the disk drive 42, and sends the monitoring result to the maintenance terminal 38 via an internal network (not shown).

The cache memory 74 is used for storing user data and the like, and is configured, for instance, from a nonvolatile memory.

The shared memory (or control memory) 76 is configured, for instance, from a nonvolatile memory. The shared memory 76 stores, for example, control information, management information, a pair information management table and a primary/secondary communication parameter table.

The switch unit 78 is used for mutually connecting the respective channel adapters 72, the respective cache memories 74, the respective shared memories 76, and the respective disk adapters 80, and is configured, for example, from an ultrafast crossbar switch. Consequently, all channel adapters 72 and disk adapters 80 are able to respectively access each cache memory 74 and each shared memory 76 via the switch unit 78.

The disk drive 42 is configured, as a memory apparatus, from a physical storage device such as a hard disk drive (HDD), a semiconductor memory, or an optical disk. The disk drive 42 may be configured from a plurality of disk drives, and a RAID

(Redundant Array of Inexpensive Disks) group as a virtual logical area may be created on a physical storage area provided by the respective disk drives 42. One or more virtual logical devices (LU: Logical Units) may be set in the RAID group. Here, the disk drive 42 functions as a secondary logical device or a secondary volume (secondary data volume).

Incidentally, a virtual logical area is referred to as a logical volume or a logical device (LDEV) in a mainframe system, and referred to as a logical unit (LU) in an open system. Thus, the wording of "primary volume" and "secondary volume" used in the claims is an appellation that covers the terms of logical volume, logical device and logical unit.

A pair information management table T1 among the various types of information stored in the shared memories 56, 76 is provided for each logical device or volume.

Each pair information management table T1 stored in the shared memories 56, 76 stores, as shown in Fig. 6, information concerning the self-volume type 100, self-volume device number 102, other volume device number 104, pair status 106, differential information address 108, and mode 110.

In the case of the pair information management table T1 of the shared memory 56, the self-volume type 100 stores the data of "00" as the self-volume since the disk drive 30 corresponds to a primary volume. In the case of the pair information management table T1 of the shared memory 76, the self-volume type 100 stores the data of "01" as the self-volume since the disk drive 42 corresponds to a secondary volume. The self-volume device number 102 stores the number of the disk drive 30.

The self-volume device number 102 stores the number of the disk drive 30 in the case of the pair information management table T1 of the shared memory 56. The other volume device number 104 stores the number of the disk drive 42 as the other volume in the case of the pair information management table T1 of the shared memory 56.

The pair status 106 stores, in both pair information management tables T1, the data of "00" if the pair status is Simplex (status where copying between the primary and secondary volumes has not yet been started), the data of "01" if the pair status is Copy, the data of "02" if the pair status is Suspend, and the data of "03" if the pair status is Pair. The differential information address 108 stores the address of the differential information (bitmap information) only in the case of the pair information management table T1 of the shared memory 76.

The mode 110 stores, in both pair information management tables T1, the data of "00" as the default value, stores the data of "01" during the minimum copy mode, and stores the data of "02" during the restoration mode. Incidentally, information concerning the pair management table T1 may also be stored in the memory of the channel adapter 52 or the disk adapter 60.

Moreover, the primary/secondary communication parameter table T2 stored in the shared memories 56, 76 is configured, as shown in Fig. 7, from an operation code 112, a primary volume device number 114, a secondary volume device number 116, and an option 118.

The operation code 112 stores the data of "00" if the status is pair creation, stores the data of "01" if the status is Suspend, stores the data of "02" if the status is Resync, and stores the data of "03" if the status is pair deletion. The primary volume device number 114 stores the number of the disk drive 30, and the secondary volume device number 116 stores the number of the disk drive 42. The option 118 stores the data of "00" if there is no option, and stores the data of "01" if the mode is a minimum copy mode.

The initial copy processing is now explained. Foremost, a pair creation screen as shown in Fig. 8 is displayed on a display screen of the maintenance terminal 24, and, if an operator selects a minimum copy 200, pair creation processing associated with such minimum copy (Min Copy) is started.

Moreover, as shown in Fig. 9, a pair creation command line 202 is displayed on a screen of the host computer 20 based on the operator's operation, and the pair creation processing associated with the minimum copy is also started when a command concerning the displayed pair creation command line 202 is input to the primary disk array device 14.

Here, minimum copy (Min Copy) is a copying process included in the remote copy, and refers to the copying where a pair is formed between the primary and secondary volumes, and, after the entire initial copy target area of the secondary volume is set to an unwritten status, data of the primary volume is copied to the secondary volume.

When the pair creation processing associated with the minimum copy is started, as processing in the primary site 1, the pair creation processing associated with the minimum copy as shown in Fig. 10 is executed.

In Fig. 10, foremost, the channel adapter 52 sets the data of "00" as the pair creation in the operation code 112 of the primary/secondary communication parameter table T2 based on the command (S1), subsequently determines whether a minimum copy command has been issued (S2), and, if a minimum copy command has been issued, sets "01" as the minimum copy mode in the option 118 of the primary/secondary communication parameter table T2 (S3).

Subsequently, the channel adapter 52 outputs a pair creation command to the secondary disk array device 16 for forming a pair with the secondary volume (S4), determines whether the pair creation command ended normally (S5), reports an error of pair creation failure to the maintenance terminal 24 or the host computer 20 if the pair creation command did not end normally (S6), and then ends this processing routine.

Meanwhile, if it is determined that the pair creation command did not end normally at step S5, the channel adapter 52 sets "00" in the self-volume type 100 of the pair information management table T1, sets the number of the disk drive 30 in the

self-volume device number 102, sets the number of the disk drive 42 in the other volume device number 104, and sets "01" representing Copy in the pair status 106 (S7).

The channel adapter 52 thereafter determines whether a minimum copy command was issued to the secondary site 2 (S8), and, if a minimum copy command has been issued, sets "01" as the minimum copy mode in the mode 110 of the pair information management table T1 (S9), and then ends this processing routine. Meanwhile, if a minimum copy command has not been issued, the channel adapter 52 implements initial copy (S10), and then ends this processing routine.

Meanwhile, the channel adapter 72 in the secondary site 2 executes the minimum copy pair creation processing as the processing in the secondary site 2.

Specifically, as shown in Fig. 11, the channel adapter 72 responds to the pair creation command from the channel adapter 52 and sets "01" as data showing the secondary volume in the self-volume type 100 of the pair creation management table T1, sets the number of the disk device 42 in the self-volume device number 102, sets the number of the disk drive 30 in the other volume device number 104, and sets "01" as data showing Copy in the pair status 106.

The channel adapter 72 thereafter determines whether the command is a minimum copy command (S22), and, if it is not a minimum copy command, ends this processing routine. Meanwhile, if it is a minimum copy command, the channel adapter 72 sets "01" as the minimum copy mode in the mode 110 of the pair information management table T1 (S23), sets all bits of the bitmap information as differential information concerning the pair between the disk drive 30 of the primary volume and the disk drive 42 of the secondary volume to an unwritten status (bits ON) (S24), and then ends this processing routine.

When the I/O processing is thereafter executed in the primary site 1 according to the I/O request from the host computer 20, data of the disk drive 30 is updated. When the data of the disk drive 30 is updated, the updated data is transferred from the

channel adapter 52 to the secondary site 2, and the remote I/O processing is executed in the secondary site 2.

The remote I/O processing in the secondary site 2 is now explained with reference to the flowchart of Fig. 12. The remote I/O processing in the secondary site 2 is executed by the channel adapter 72 and the disk adapter 80.

Specifically, when the channel adapter 72 receives the updated data and the command from the primary site 1, it writes the received data into the cache memory 74 based on the received command (S31). Here, the disk adapter 80 determines whether minimum copy or restoration is currently being performed (S32), and, if it is determined that minimum copy is being performed, the disk adapter 80 performs processing for writing the update data into a designated storage location of the disk drive 42 (S33).

Incidentally, at step S32, the differential information (bitmap information) corresponding to the write location of the update data is set to a written status, or an OFF state. Moreover, if it is determined that restoration is being performed at step S32, the disk adapter 72 ends this processing routine without writing the update data from the primary site 1 into the disk drive 42.

Subsequently, in the course of the update data being sent from the primary site 1 to the secondary site 2, if a backup request from the host computer 20 is input to the primary site 1, the channel adapter 52 transfers the data stored in the disk drive 30 as backup data to the host computer 20 of the backup requestor. Consequently, the host computer 20 copies the backup data to the external memory medium 44, and backs up the data of the disk drive 30 as backup data to the external memory medium 44.

After the backup data is recorded therein, the external memory medium 44 is transported to the secondary site 2 with a transportation means such as a vehicle, and then connected to the host computer 34.

When the external memory medium 44 is connected to the host computer 34, if a restoration mode ON 204 is selected on the operation screen pursuant to a command

from the host computer 34 or the maintenance terminal 24; for instance, by the operator of the maintenance terminal 24 as shown in Fig. 13, processing for switching the secondary site 2 from the minimum copy mode to the restoration mode is performed.

The restoration mode ON processing is now explained with reference to the flowchart of Fig. 14. Foremost, the channel adapter 72 responds to the command from the host computer 34 or the maintenance terminal 24 and determines whether the minimum copy is currently being performed (S41). If it is determined that the minimum copy is being performed, the channel adapter 72 sets "02" representing restoration in the mode 110 of the pair information management table T1 in order to shift from the minimum copy mode to the restoration mode, and then ends this processing routine (S42). If it is determined that the minimum copy is not being performed, since it is not possible to shift to the restoration mode, the channel adapter 72 reports an error to the host computer 34 or the maintenance terminal 24 (S43), and then ends this processing routine.

The restoration processing is now explained with reference to the flowchart of Fig. 15. Foremost, the channel adapter 72 imports the differential information (bitmap information), and determines whether the differential bits are ON (S51). If the differential bits are not ON, the channel adapter 72 ends this processing routine. Meanwhile, if the differential bits are ON, the channel adapter 72 writes the received data (update data) that was received in the secondary site 2 into the cache memory 74 (S52).

The channel adapter 72 thereafter determines whether the mode is currently in the restoration mode (S53). If the mode is not in the restoration mode, the channel adapter 72 ends this processing routine. Meanwhile, if the mode is in the restoration mode, the channel adapter 72 sets the bits as differential information at the write location to OFF based on the received data written into the cache memory 74 (S54), and then ends this processing routine.

The restoration mode OFF processing is now explained with reference to the flowchart of Fig. 16. The restoration mode OFF processing is started, as shown in Fig. 13, when the operator selects a restoration mode OFF 206 on the operation screen of the maintenance terminal 24.

Foremost, the channel adapter 72 determines whether the mode is currently in the restoration mode (S61). If it is determined that the mode is not in the restoration mode, the channel adapter 72 reports an error to the host computer 34 or the maintenance terminal 24 since it is not possible to cancel the restoration mode (S62), and then ends this processing routine.

Meanwhile, if it is determined that the mode is in the restoration mode, the channel adapter 72 determines whether the bits of all differential information (bitmap information) are OFF (S63). If all bits of the differential information are not OFF, the channel adapter 72 determines this to be a minimum copy mode and proceeds to the minimum copy processing (S64), and then ends this processing routine.

Meanwhile, if it is determined that all bits of the differential information (bitmap information) are OFF at step 63, the channel adapter 72 sets "03" as the pair status in the pair status 106 of the pair management table T1, sets "00" as the data showing the default value in the mode 110 (S65), and then ends this processing routine.

Subsequently, on the condition that all bits of the differential information are in an OFF state, the remote copy is complete.

Incidentally, information such as the control information, management information or pair information management table and primary/secondary communication parameter table may also be stored in the memory of the channel adapters 52, 72 or the memory of the disk adapters 60, 80, or stored in another dedicated memory.

In addition, in substitute for the microprocessor of the channel adapters 52, 72 and disk adapters 60, 80, a dedicated microprocessor may be provided to each disk

array device 14, 16, and each microprocessor may be used as the controller to execute the processing related to the initial copy.

For example, a microprocessor comprising the functions of the microprocessor of the channel adapter 52 and the microprocessor of the disk adapter 60 may be used as the primary controller, and a microprocessor comprising the functions of the microprocessor of the channel adapter 72 and the microprocessor of the disk adapter 80 may be used as the secondary controller.

In the foregoing case, the primary controller issues a pair creation command to the secondary controller prior to remote-copying data of the primary volume to the secondary volume, commands the copying of the update data updated after the foregoing pair creation command was issued, and subsequently responds to the backup request from the backup requestor and outputs the data of the primary volume as backup data to the backup requestor.

In addition, the secondary controller responds to the pair creation command from the primary controller and sets the entire initial copy target area of the secondary volume to an unwritten status, and thereafter copies the update data updated by the primary controller as differential information to the initial copy target area of the secondary volume. After completing the copy of such differential information, if backup data is input as data from the external memory medium 44 recording the backup data, data among the foregoing backup data that is different from the differential information is written into the secondary volume.

Moreover, if the secondary controller receives from the primary controller a command for copying the update data, it copies the update data sent from the primary controller to the initial copy target area of the secondary volume, and sets the bits corresponding to the storage location of the update data among the differential information to an OFF state. If the secondary controller thereafter receives from the maintenance terminal 24 or the host computer 20 a command for restoring the backup

data stored in the external memory medium 44 to the secondary volume 42, it copies the backup data to the areas within the initial copy target area of the secondary volume 42 where the bits of differential information are in an ON state, and sets the bits corresponding to the storage location of the backup data among the differential information to an OFF state.

Consequently, the primary controller and the secondary controller complete the remote copy on the condition that all bits of the differential information are in an OFF state.

According to the present embodiment, it is possible to reduce the processing required for the initial copy.

In addition, according to the present embodiment, it is also possible to reduce the data traffic associated with the initial copy, and reduce the traffic charge upon using the communication network.

CLAIMS

1. A storage system, comprising:

a primary disk subsystem installed at a primary site; and

a secondary disk subsystem installed at a secondary site and connected to the primary disk subsystem via a communication medium;

wherein the primary disk subsystem includes a primary volume created from a plurality of disk devices, and a primary controller for controlling the primary volume and sending and receiving data to and from the secondary disk subsystem via the communication medium;

wherein the secondary disk subsystem includes a secondary volume created from a plurality of disk devices, and a secondary controller for controlling the volume and sending and receiving data to and from the primary disk subsystem via the communication medium;

wherein the primary controller issues a pair creation command to the secondary controller prior to remote-copying data of the primary volume to the secondary volume, commands the copying of update data that was updated after the pair creation command was issued, and subsequently responds to a backup request from a backup requestor and outputs data of the primary volume as backup data to the backup requestor; and

wherein the secondary controller responds to the pair creation command from the primary controller and sets the entire initial copy target area of the secondary volume to an unwritten status, thereafter copies the update data updated by the primary controller as differential information to the initial copy target area of the secondary volume, and, if data from an external memory medium recording the backup data is input as the backup data, writes data that differs from the differential information among the backup data into the secondary volume.

2. The storage system according to claim 1,

wherein the primary controller comprises a primary channel adapter for outputting a command to the secondary controller for the pair creation or the copying of the update data, and outputting data of the primary volume as backup data to a host computer of the backup requestor, and a primary disk adapter for controlling the primary volume;

wherein the secondary controller comprises a secondary channel adapter for inputting and processing commands and data from the primary channel adapter, and a secondary disk adapter for controlling the secondary volume; and

wherein the secondary disk adapter sets the entire initial copy target area of the secondary volume to an unwritten status and sets all bits of differential information for managing information of the initial copy target area to an ON state when the secondary channel adapter receives a pair creation command from the primary channel adapter, thereafter copies the update data sent from the primary channel adapter to the initial copy target area of the secondary volume and sets bits corresponding to a storage location of the update data among the differential information to an OFF state when the secondary channel adapter receives a command for copying the update data from the primary channel adapter, subsequently copies the backup data to areas where bits of the differential information are in an ON state within the initial copy target area of the secondary volume and sets bits corresponding to a storage location of the backup data among the differential information to an OFF state when the secondary channel adapter receives a command for restoring the backup data stored in the external memory medium to the secondary volume, and thereby completes the remote copy on the condition that all bits of the differential information are in an OFF state.

3. The storage system according to claim 1,

wherein the primary controller outputs the pair creation command to the secondary controller according to a command from a maintenance terminal connected

to a communication medium or a host computer connected to a communication medium.

4. The storage system according to claim 1,

wherein the secondary controller sets the entire initial copy target area of the secondary volume to an unwritten status and sets all bits of differential information for managing information of the initial copy target area to an ON state upon receiving the pair creation command from the primary controller.

5. The storage system according to claim 1,

wherein the secondary controller sets the entire initial copy target area of the secondary volume to an unwritten status and sets all bits of differential information for managing information of the initial copy target area to an ON state upon receiving the pair creation command from the primary controller, and thereafter copies the update data sent from the primary controller to the initial copy target area of the secondary volume and sets bits corresponding to a storage location of the update data among the differential information to an OFF state upon receiving a command for copying the update data from the primary controller.

6. The storage system according to claim 1,

wherein the secondary controller sets the entire initial copy target area of the secondary volume to an unwritten status and sets all bits of differential information for managing information of the initial copy target area to an ON state upon receiving the pair creation command from the primary controller, thereafter copies the update data sent from the primary controller to the initial copy target area of the secondary volume and sets bits corresponding to a storage location of the update data among the differential information to an OFF state upon receiving a command for copying the update data from the primary controller, and subsequently copies the backup data to areas where bits of the differential information are in an ON state within the initial copy target area of the secondary volume and sets bits corresponding to a storage location of

the backup data among the differential information to an OFF state upon receiving a command for restoring backup data stored in the external memory medium to the secondary volume from a maintenance terminal connected to a communication medium or a host computer connected to a communication medium.

7. The storage system according to claim 1,

wherein the secondary controller sets the entire initial copy target area of the secondary volume to an unwritten status and sets all bits of differential information for managing information of the initial copy target area to an ON state upon receiving the pair creation command from the primary controller, thereafter copies the update data sent from the primary controller to the initial copy target area of the secondary volume and sets bits corresponding to a storage location of the update data among the differential information to an OFF state upon receiving a command for copying the update data from the primary controller, and subsequently copies the backup data to areas where bits of the differential information are in an ON state within the initial copy target area of the secondary volume and sets bits corresponding to a storage location of the backup data among the differential information to an OFF state upon receiving a command for restoring backup data stored in the external memory medium to the secondary volume from a maintenance terminal connected to a communication medium or a host computer connected to a communication medium; and

wherein the primary controller and the secondary controller thereby complete the remote copy on the condition that all bits of the differential information are in an OFF state.

8. An initial copy method of a storage system comprising a primary disk subsystem installed at a primary site, and a secondary disk subsystem installed at a secondary site and connected to the primary disk subsystem via a communication medium;

wherein the primary disk subsystem includes a primary volume created from a plurality of disk devices, and a primary controller for controlling the primary volume and

sending and receiving data to and from the secondary disk subsystem via the communication medium;

wherein the secondary disk subsystem includes a secondary volume created from a plurality of disk devices, and a secondary controller for controlling the volume and sending and receiving data to and from the primary disk subsystem via the communication medium;

wherein the primary controller executes:

a step of issuing a pair creation command to the secondary controller prior to remote-copying data of the primary volume to the secondary volume;

a step of commanding the copying of update data that was updated after the pair creation command was issued; and

a step of subsequently responding to a backup request from a backup requestor and outputting data of the primary volume as backup data to the backup requestor;

wherein the secondary controller executes:

a step of responding to the pair creation command from the primary controller and setting the entire initial copy target area of the secondary volume to an unwritten status;

a step of thereafter copying the update data updated by the primary controller as differential information to the initial copy target area of the secondary volume; and

if data from an external memory medium recording the backup data is input as the backup data, a step of writing data that differs from the differential information among the backup data into the secondary volume.

9. The initial copy method of a storage system according to claim 8,

wherein the secondary controller executes:

a step of setting the entire initial copy target area of the secondary volume to an unwritten status and setting all bits of differential information for managing information of the initial copy target area to an ON state upon receiving the pair creation command

from the primary controller;

a step of thereafter copying the update data sent from the primary controller to the initial copy target area of the secondary volume and setting bits corresponding to a storage location of the update data among the differential information to an OFF state upon receiving a command for copying the update data from the primary controller; and

a step of subsequently copying the backup data to areas where bits of the differential information are in an ON state within the initial copy target area of the secondary volume and setting a bit corresponding to a storage location of the backup data among the differential information to an OFF state upon receiving a command for restoring backup data stored in the external memory medium to the secondary volume from a maintenance terminal connected to a communication medium or a host computer connected to a communication medium.

10. The initial copy method of a storage system according to claim 8,

wherein the secondary controller executes:

a step of setting the entire initial copy target area of the secondary volume to an unwritten status and setting all bits of differential information for managing information of the initial copy target area to an ON state upon receiving the pair creation command from the primary controller;

a step of thereafter copying the update data sent from the primary controller to the initial copy target area of the secondary volume and setting bits corresponding to a storage location of the update data among the differential information to an OFF state upon receiving a command for copying the update data from the primary controller; and

a step of subsequently copying the backup data to areas where bits of the differential information are in an ON state within the initial copy target area of the secondary volume and setting a bit corresponding to a storage location of the backup data among the differential information to an OFF state upon receiving a command for restoring backup data stored in the external memory medium to the secondary volume

from a maintenance terminal connected to a communication medium or a host computer connected to a communication medium; and

wherein the primary controller and the secondary controller execute a step of completing the remote copy on the condition that all bits of the differential information are in an OFF state.

FIG.1

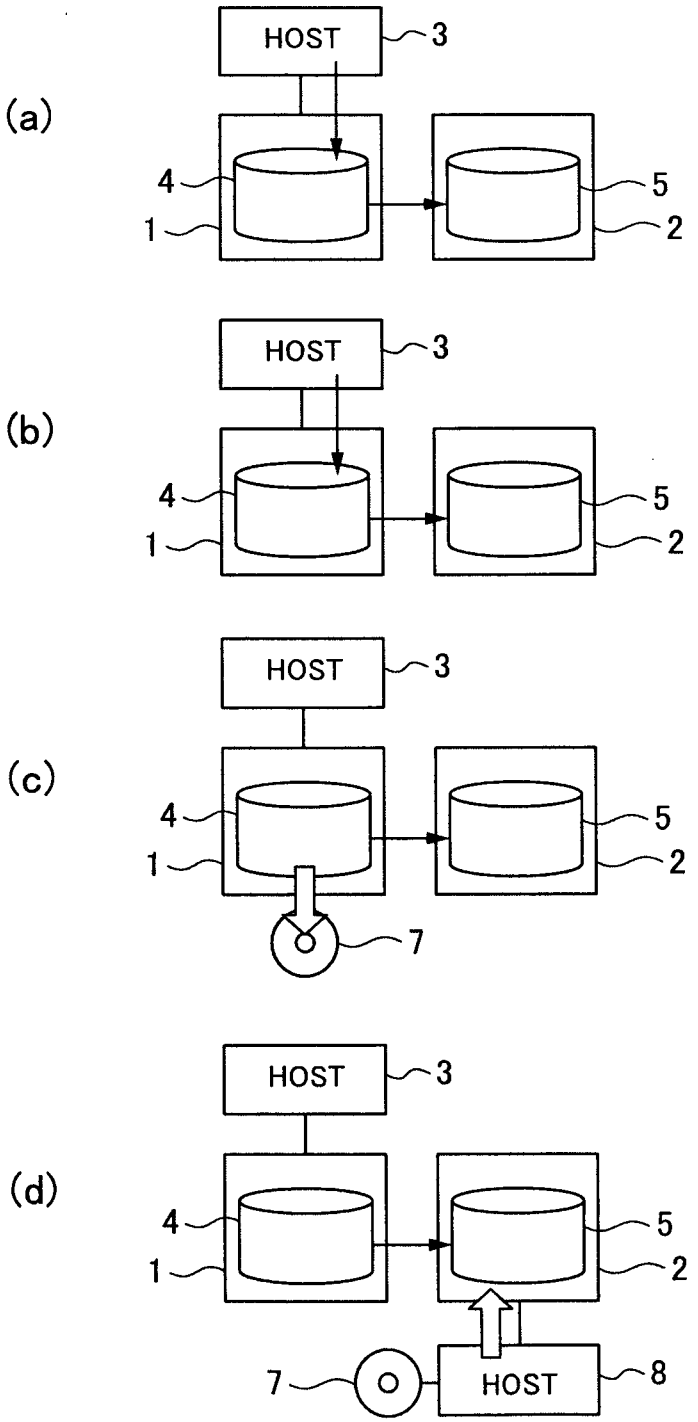


FIG.2

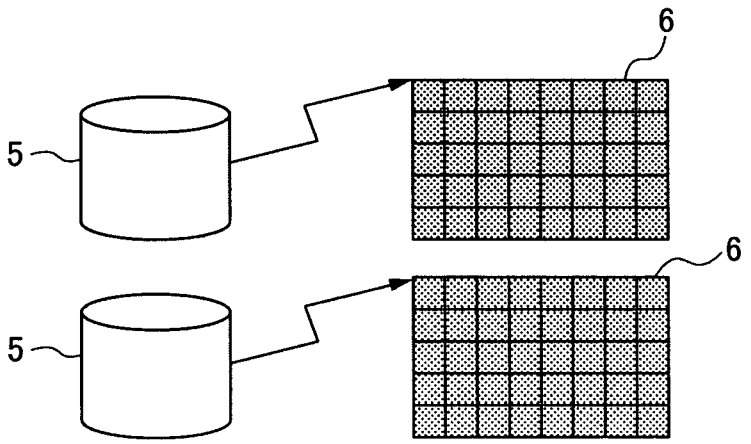


FIG.3

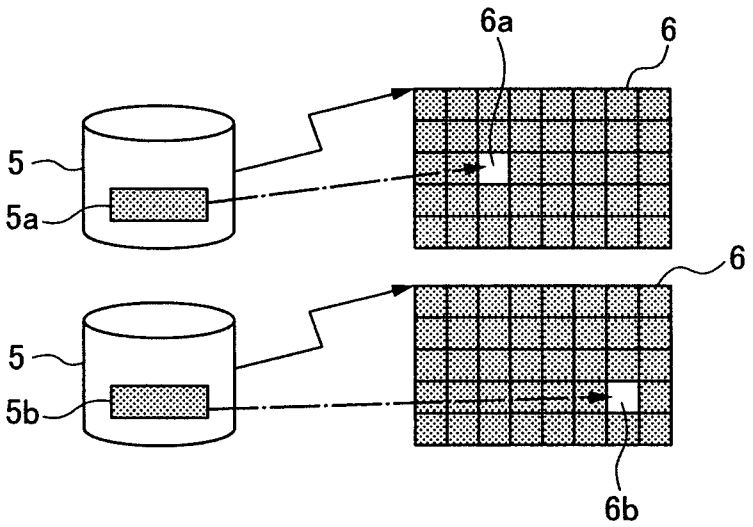


FIG.4

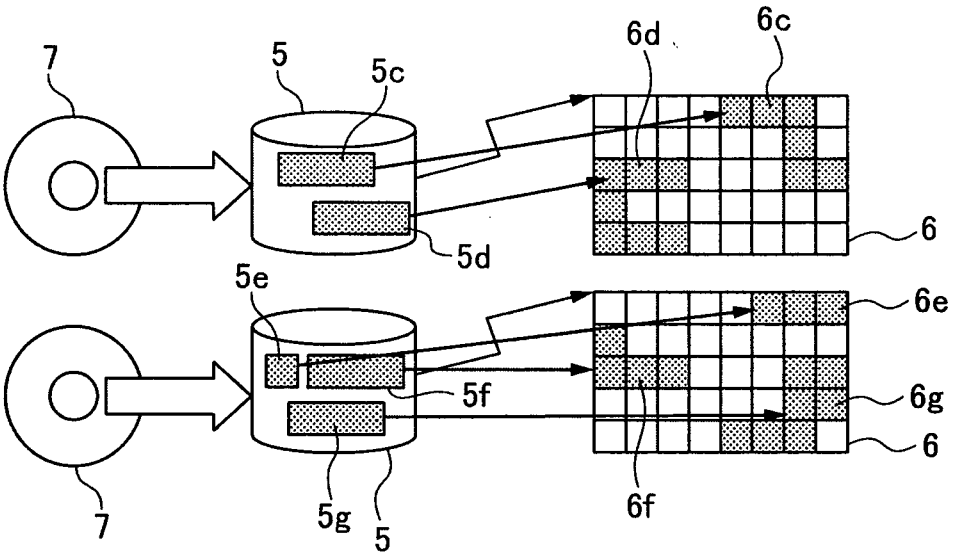


FIG.5

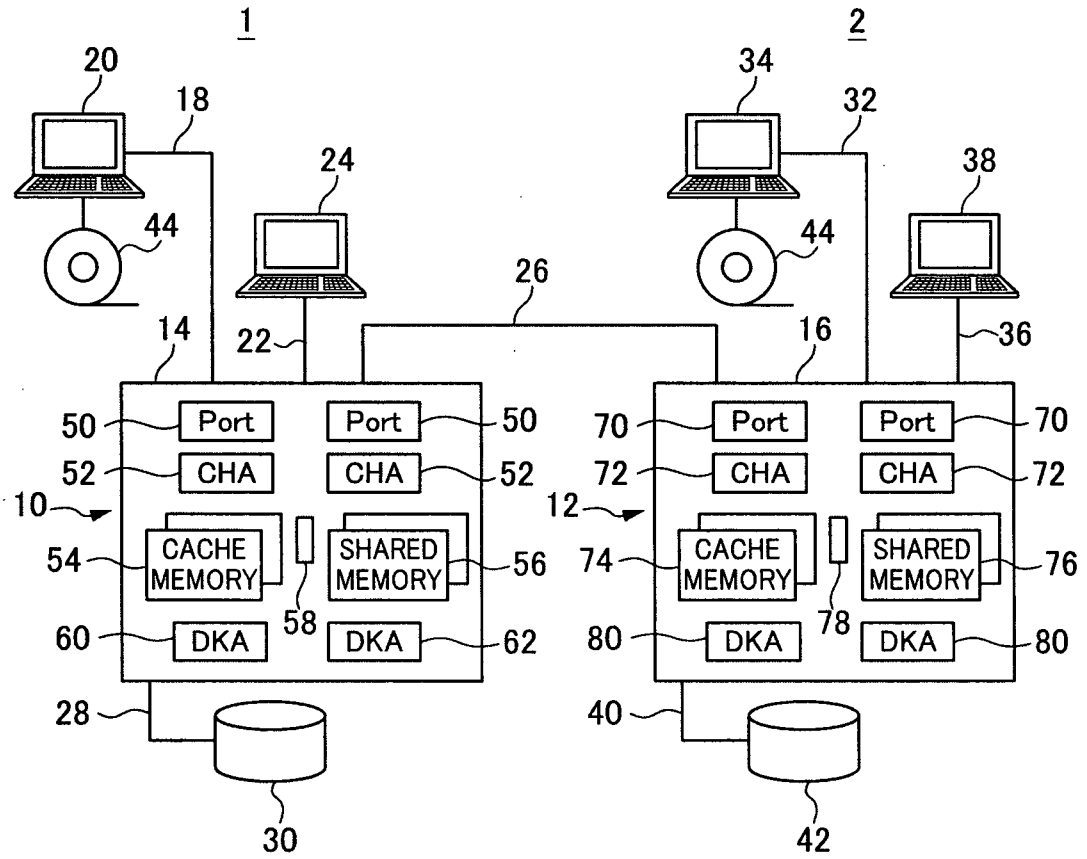

1
2
20
18
24
44
34
32
38
44
26
14
22
16
36
50
Port
Port
50
70
Port
Port
70
52
CHA
CHA
52
72
CHA
CHA
72
10
12
54
CACHE MEMORY
58
SHARED MEMORY
56
74
CACHE MEMORY
78
SHARED MEMORY
76
60
DKA
DKA
62
80
DKA
DKA
80
28
40
30
42

FIG.6

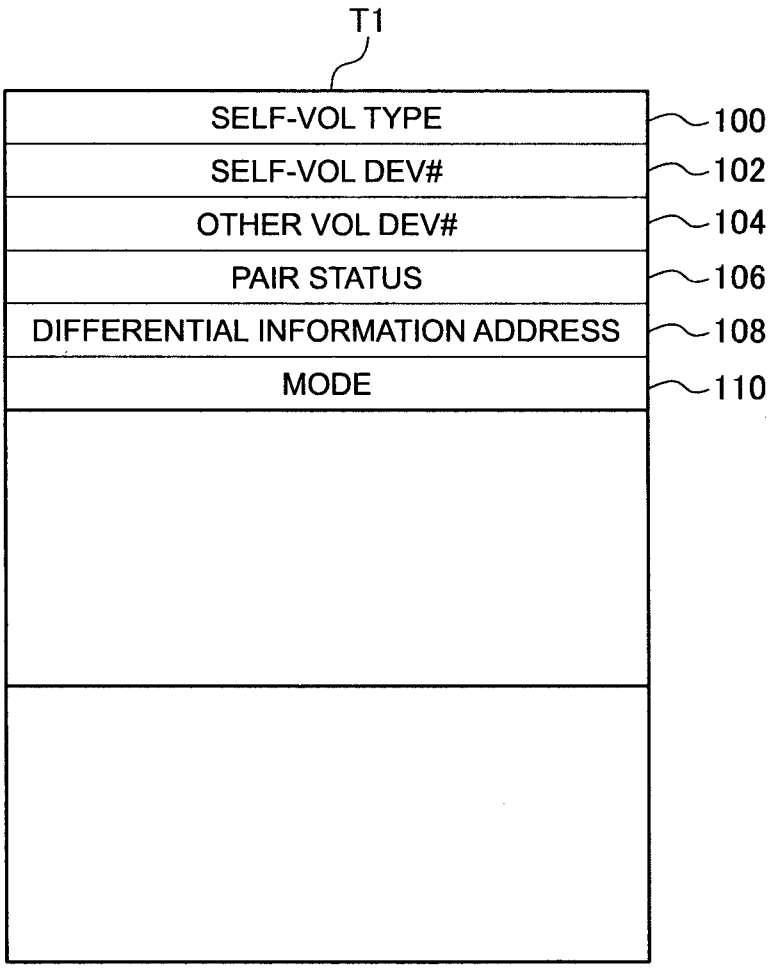

T1
SELF-VOL TYPE
100
SELF-VOL DEV#
102
OTHER VOL DEV#
104
PAIR STATUS
106
DIFFERENTIAL INFORMATION ADDRESS
108
MODE
110

FIG.7

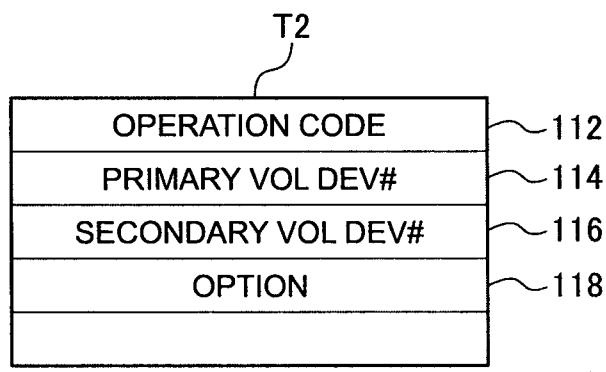

T2
OPERATION CODE
112
PRIMARY VOL DEV#
114
SECONDARY VOL DEV#
116
OPTION
118

FIG.8

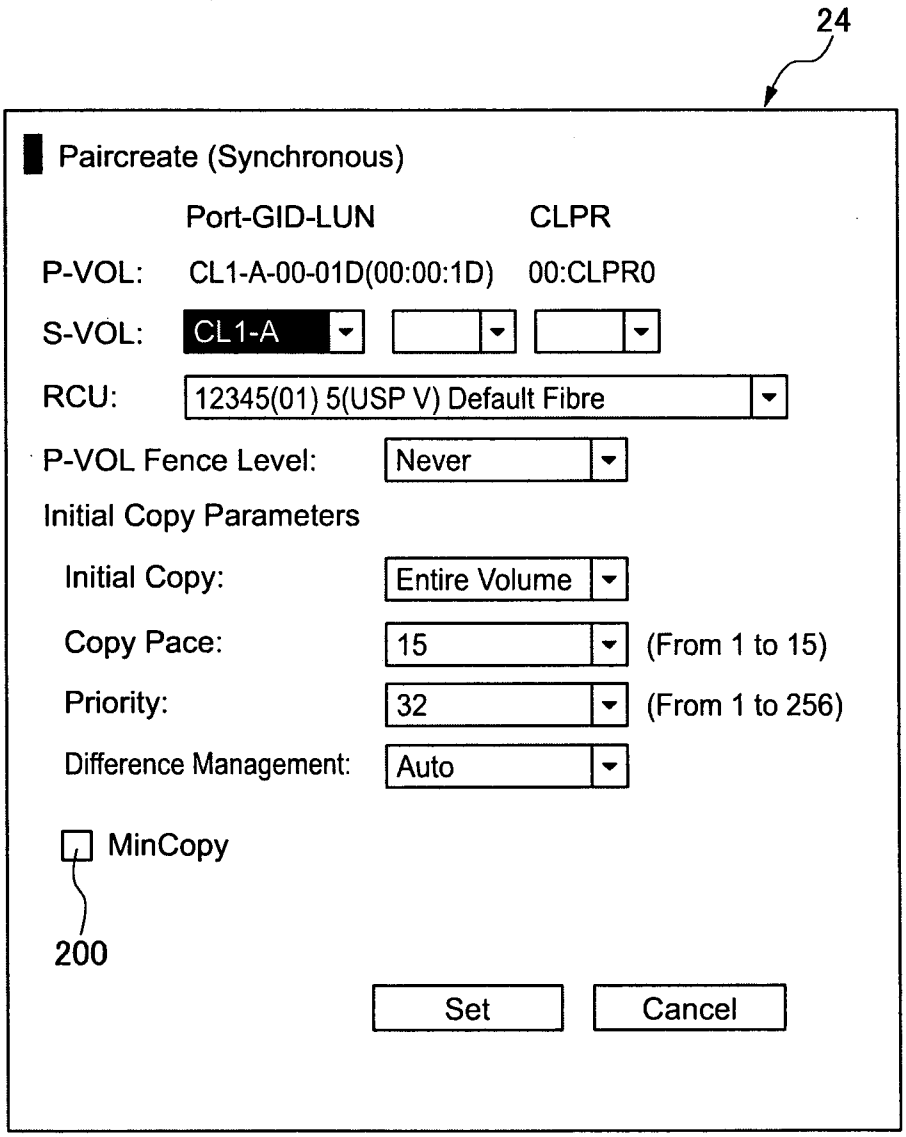

24
Paircreate (Synchronous)
Port-GID-LUN
CLPR
P-VOL:
CL1-A-00-01D(00:00:1D)
00:CLPR0
S-VOL:
CL1-A
RCU:
12345(01) 5(USP V) Default Fibre
P-VOL Fence Level:
Never
Initial Copy Parameters
Initial Copy:
Entire Volume
Copy Pace:
15
(From 1 to 15)
Priority:
32
(From 1 to 256)
Difference Management:
Auto
MinCopy
200
Set
Cancel

FIG.9

202 paircreate-g Oradb-f never-vl-mincopy

FIG.10

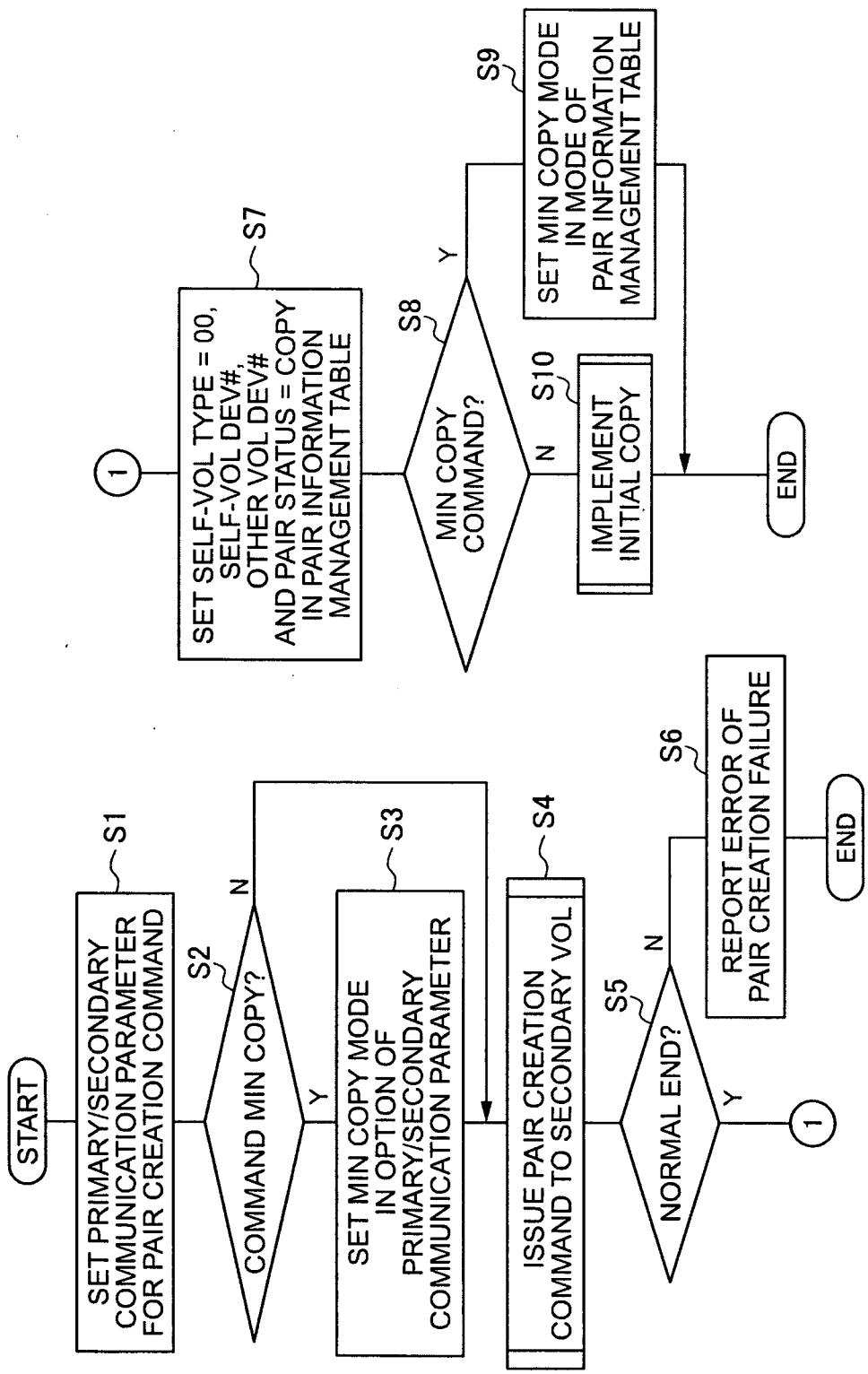

START
SET PRIMARY/SECONDARY COMMUNICATION PARAMETER FOR PAIR CREATION COMMAND
S1
COMMAND MIN COPY?
S2
N
Y
SET MIN COPY MODE IN OPTION OF PRIMARY/SECONDARY COMMUNICATION PARAMETER
S3
ISSUE PAIR CREATION COMMAND TO SECONDARY VOL
S4
NORMAL END?
S5
N
Y
REPORT ERROR OF PAIR CREATION FAILURE
S6
END
1
1
SET SELF-VOL TYPE = 00, SELF-VOL DEV#, OTHER VOL DEV# AND PAIR STATUS = COPY IN PAIR INFORMATION MANAGEMENT TABLE
S7
MIN COPY COMMAND?
S8
Y
N
SET MIN COPY MODE IN MODE OF PAIR INFORMATION MANAGEMENT TABLE
S9
IMPLEMENT INITIAL COPY
S10
END

FIG.11

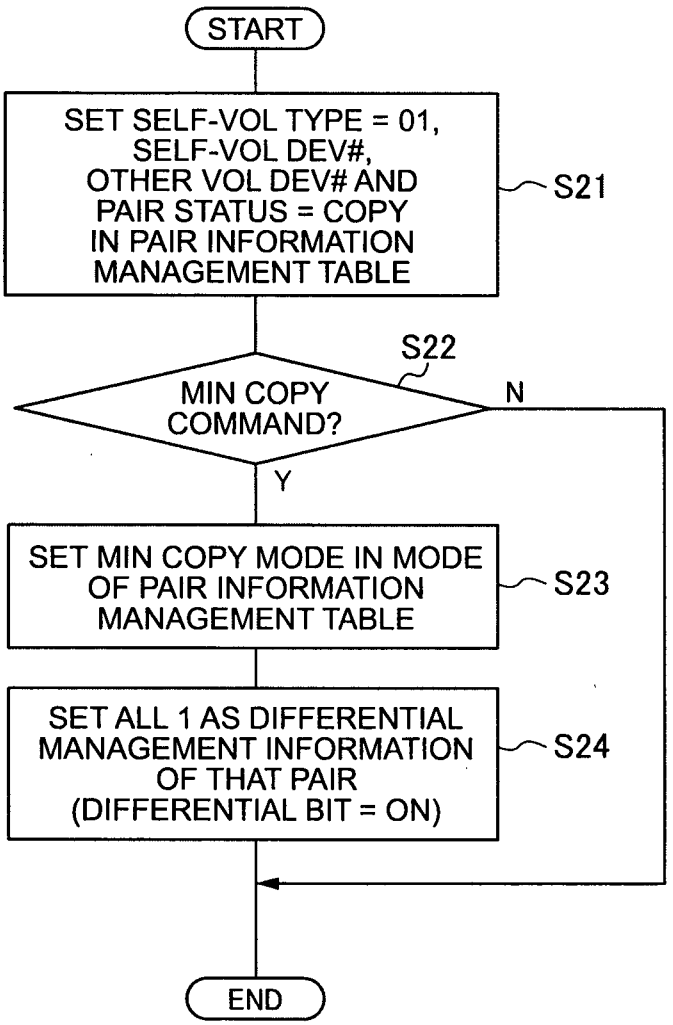

START
SET SELF-VOL TYPE = 01, SELF-VOL DEV#, OTHER VOL DEV# AND PAIR STATUS = COPY IN PAIR INFORMATION MANAGEMENT TABLE
S21
S22
MIN COPY COMMAND?
N
Y
SET MIN COPY MODE IN MODE OF PAIR INFORMATION MANAGEMENT TABLE
S23
SET ALL 1 AS DIFFERENTIAL MANAGEMENT INFORMATION OF THAT PAIR (DIFFERENTIAL BIT = ON)
S24
END

FIG.12

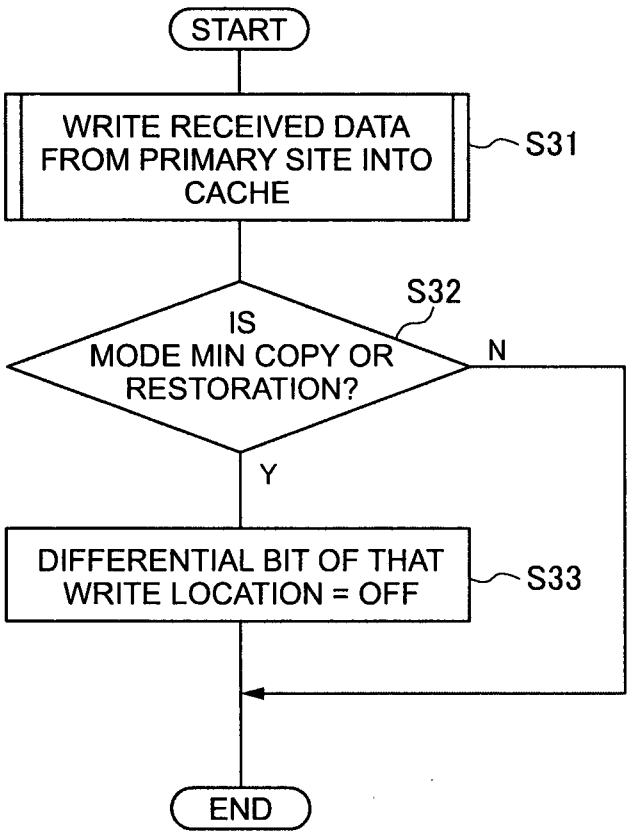

START
WRITE RECEIVED DATA FROM PRIMARY SITE INTO CACHE
S31
S32
IS MODE MIN COPY OR RESTORATION?
N
Y
DIFFERENTIAL BIT OF THAT WRITE LOCATION = OFF
S33
END

FIG.13

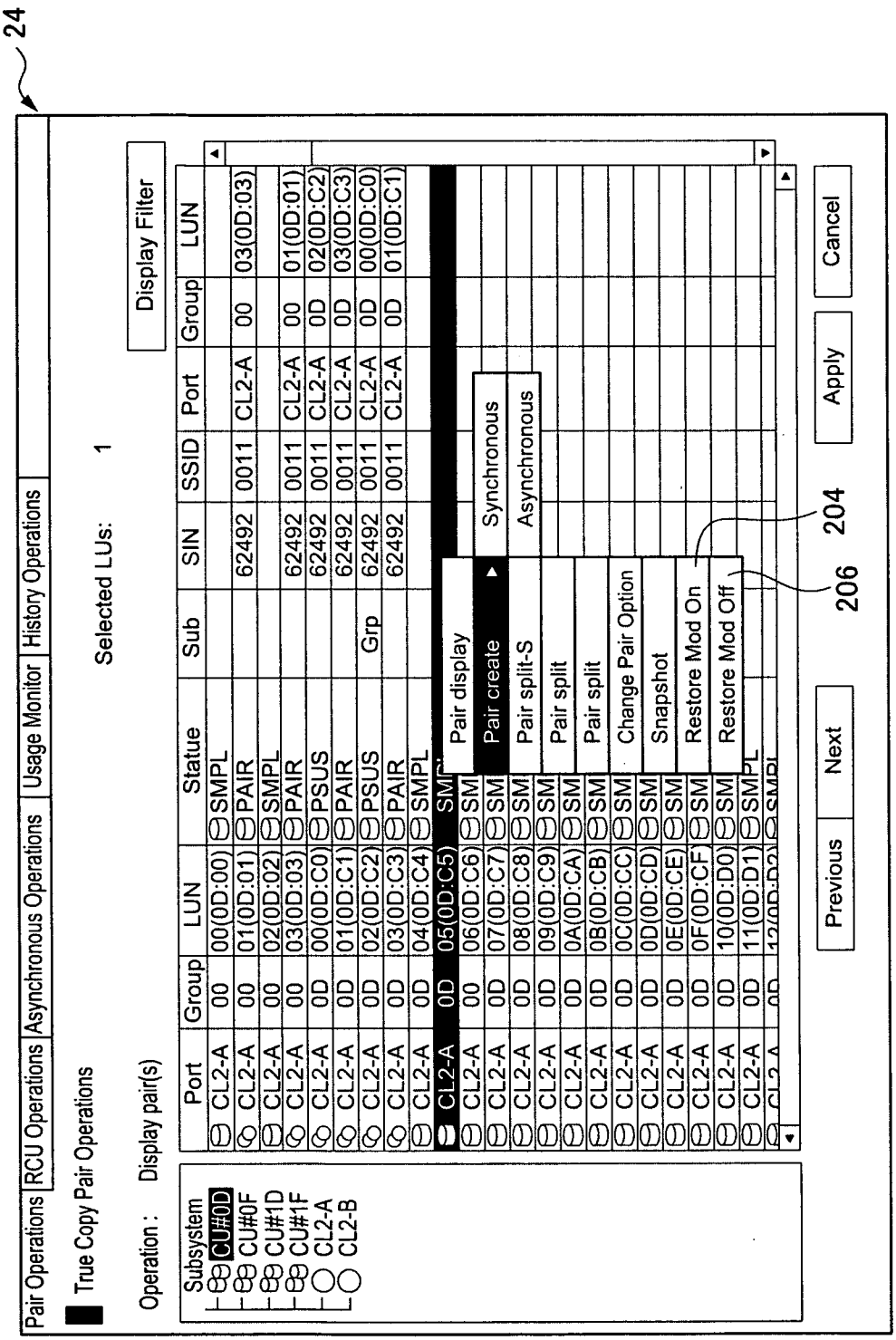

24
Pair Operations
RCU Operations
Asynchronous Operations
Usage Monitor
History Operations
True Copy Pair Operations
Selected LUs: 1
Display Filter
Operation : Display pair(s)
Subsystem
CU#0D
CU#0F
CU#1D
CU#1F
CL2-A
CL2-B
Port
Group
LUN
Statue
Sub
SIN
SSID
Port
Group
LUN
Pair display
Pair create
Pair split-S
Pair split
Pair split
Change Pair Option
Snapshot
Restore Mod On
Restore Mod Off
Synchronous
Asynchronous
204
206
Previous
Next
Apply
Cancel

FIG.14

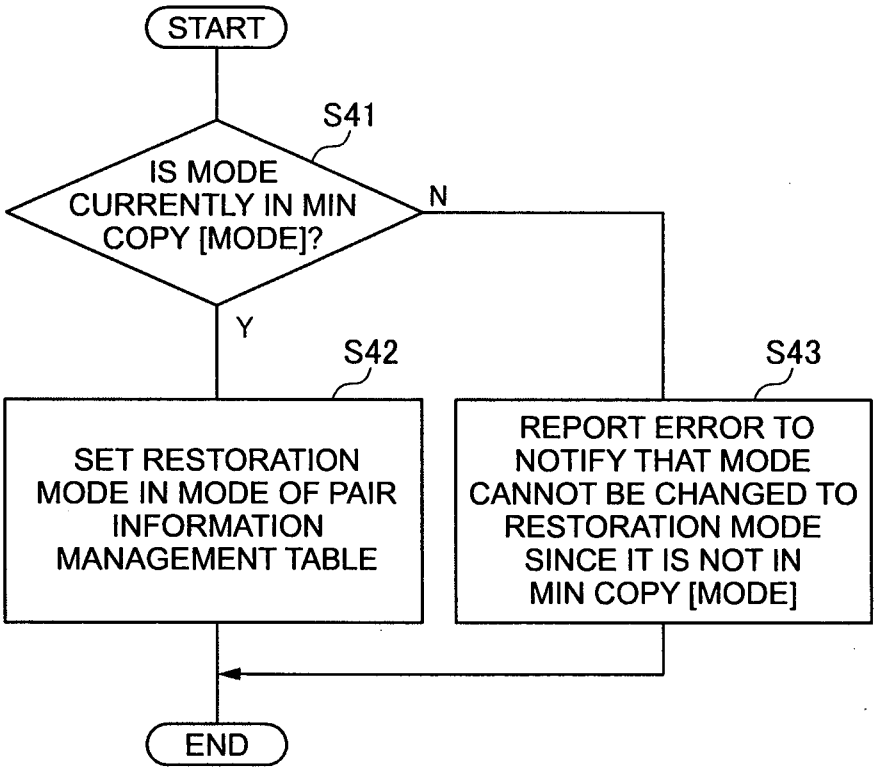

START
S41
IS MODE CURRENTLY IN MIN COPY [MODE]?
N
Y
S42
SET RESTORATION MODE IN MODE OF PAIR INFORMATION MANAGEMENT TABLE
S43
REPORT ERROR TO NOTIFY THAT MODE CANNOT BE CHANGED TO RESTORATION MODE SINCE IT IS NOT IN MIN COPY [MODE]
END

FIG.15

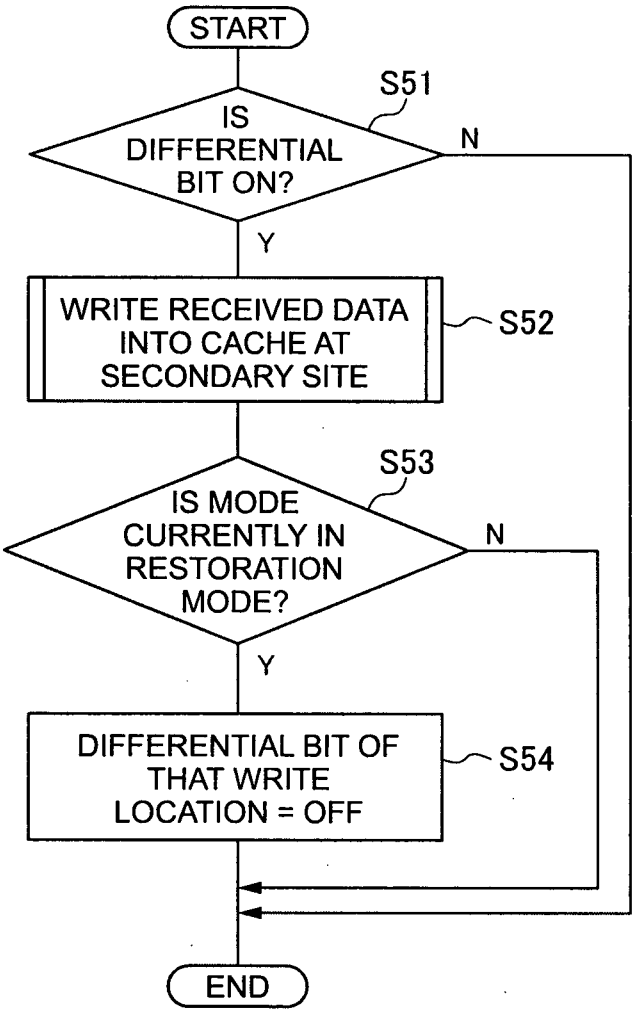
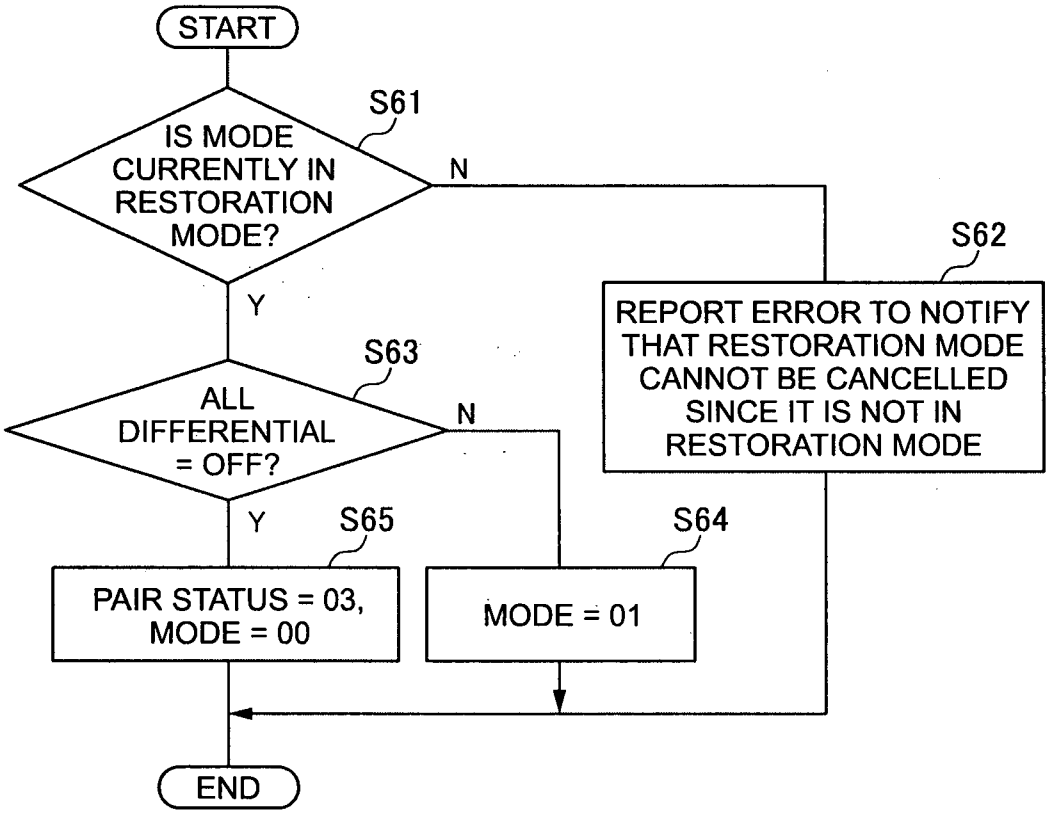

START
S51
IS DIFFERENTIAL BIT ON?
N
Y
WRITE RECEIVED DATA INTO CACHE AT SECONDARY SITE
S52
S53
IS MODE CURRENTLY IN RESTORATION MODE?
N
Y
DIFFERENTIAL BIT OF THAT WRITE LOCATION = OFF
S54
END

FIG.16


START
S61
IS MODE CURRENTLY IN RESTORATION MODE?
N
S62
REPORT ERROR TO NOTIFY THAT RESTORATION MODE CANNOT BE CANCELLED SINCE IT IS NOT IN RESTORATION MODE
Y
S63
ALL DIFFERENTIAL = OFF?
N
Y
S65
PAIR STATUS = 03, MODE = 00
S64
MODE = 01
END

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2009/054219

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F11/20 G06F11/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7 434 093 B2 (OHRAN RICHARD S [US]) 7 October 2008 (2008-10-07) column 1, lines 46-67 column 2, lines 32-35 column 3, lines 29-67 column 4, line 45 - column 6, line 45 column 7, line 9 - column 8, line 12 figures 1,2,3A,3B	1-10
Y	US 6 073 221 A (BEAL DAVID GRANT [US] ET AL) 6 June 2000 (2000-06-06) column 1, lines 22-37 column 2, lines 2-7 column 2, lines 39-42 column 2, lines 61-64 column 3, lines 21-25 column 3, lines 51-56	1-10

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 July 2009	08/07/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Fax: (+31–70) 340–3016	Lanchès, Philippe

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2009/054219

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2003/014534 A1 (WATANABE NAOKI [US] ET AL) 16 January 2003 (2003-01-16)	2
A	paragraphs [0004], [0009], [0010], [0033], [0041], [0046] - [0049], [0055], [0058], [0065] figures 1,3,5,7	3-10
A	US 7 032 089 B1 (RANADE DILIP M [IN] ET AL) 18 April 2006 (2006-04-18) column 3, lines 17-22	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/JP2009/054219

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7434093 B2	07-10-2008	AU 3100002 A	01-07-2002
		CA 2432385 A1	27-06-2002
		CN 1481534 A	10-03-2004
		EP 1344154 A1	17-09-2003
		JP 4142438 B2	03-09-2008
		JP 2004516580 T	03-06-2004
		WO 0250716 A1	27-06-2002
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