US009690735B2

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Umezuki et al.

(10) **Patent No.: US 9,690,735 B2**
(45) **Date of Patent: Jun. 27, 2017**

(54) **SWITCH AND CONTROL METHOD**

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(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 360 days.

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(22) Filed: **Jun. 23, 2014**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

G06F 3/00	(2006.01)
G06F 13/28	(2006.01)
G06F 5/00	(2006.01)
G06F 13/40	(2006.01)
G06F 1/26	(2006.01)

(52) **U.S. Cl.**

CPC ***G06F 13/4022*** (2013.01); ***G06F 1/266*** (2013.01); *Y02B 60/1228* (2013.01); *Y02B 60/1235* (2013.01)

(58) **Field of Classification Search**

CPC G06F 3/061; G06F 11/142; G06F 13/24

USPC 710/260, 26, 3, 4, 9, 36

See application file for complete search history.

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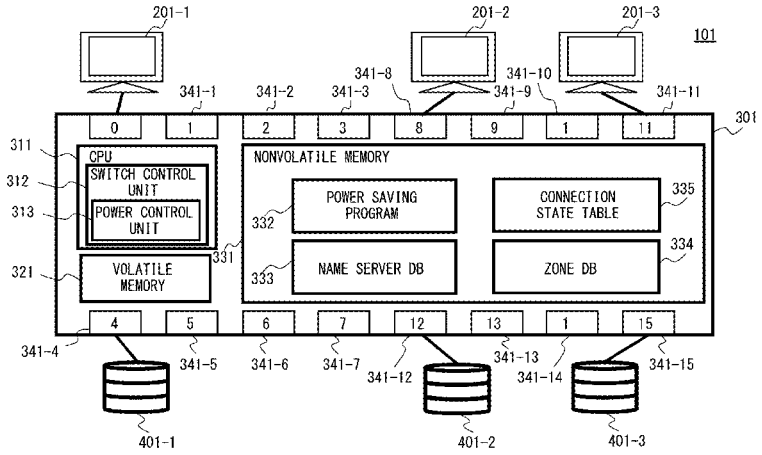
(57) **ABSTRACT**

A switch connected to an external device, the switch including: a plurality of ports connected to the external devices; a storage unit to store a zone database indicating a group in which each of the plurality of ports is included; and a processor to perform power control of the plurality of ports and permit communication between only ports included in the same group, on the basis of the zone database, wherein the processor powers off a port that is not included in any group among the plurality of ports, on the basis of the zone database.

8 Claims, 23 Drawing Sheets



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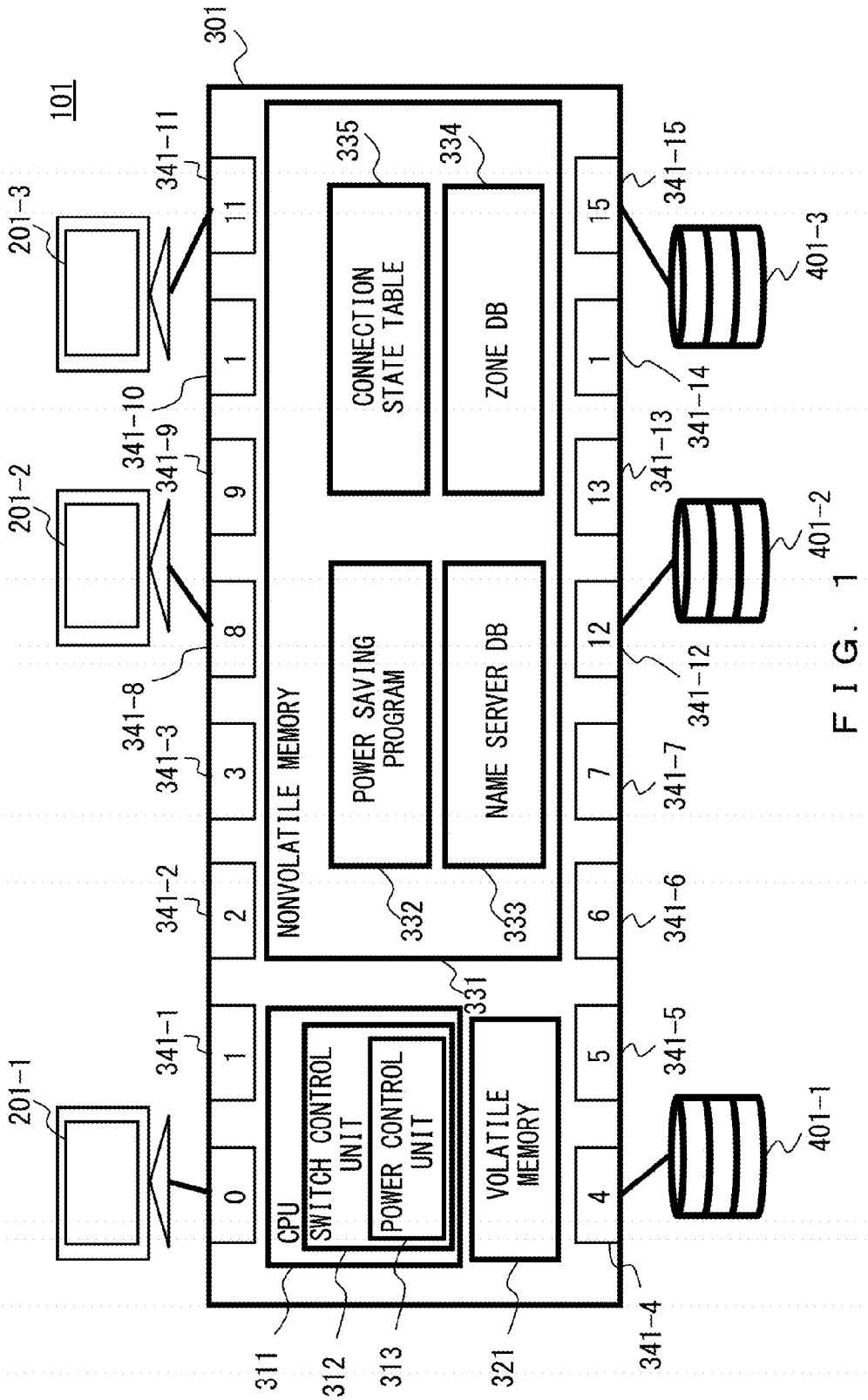

101
301
NONVOLATILE MEMORY
CONNECTION STATE TABLE
ZONE DB
POWER SAVING PROGRAM
NAME SERVER DB
CPU
SWITCH CONTROL UNIT
POWER CONTROL UNIT
VOLATILE MEMORY
331
332
333
334
335
311
312
313
321
201-1
201-2
201-3
401-1
401-2
401-3
341-1
341-2
341-3
341-4
341-5
341-6
341-7
341-8
341-9
341-10
341-11
341-12
341-13
341-14
341-15
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 1

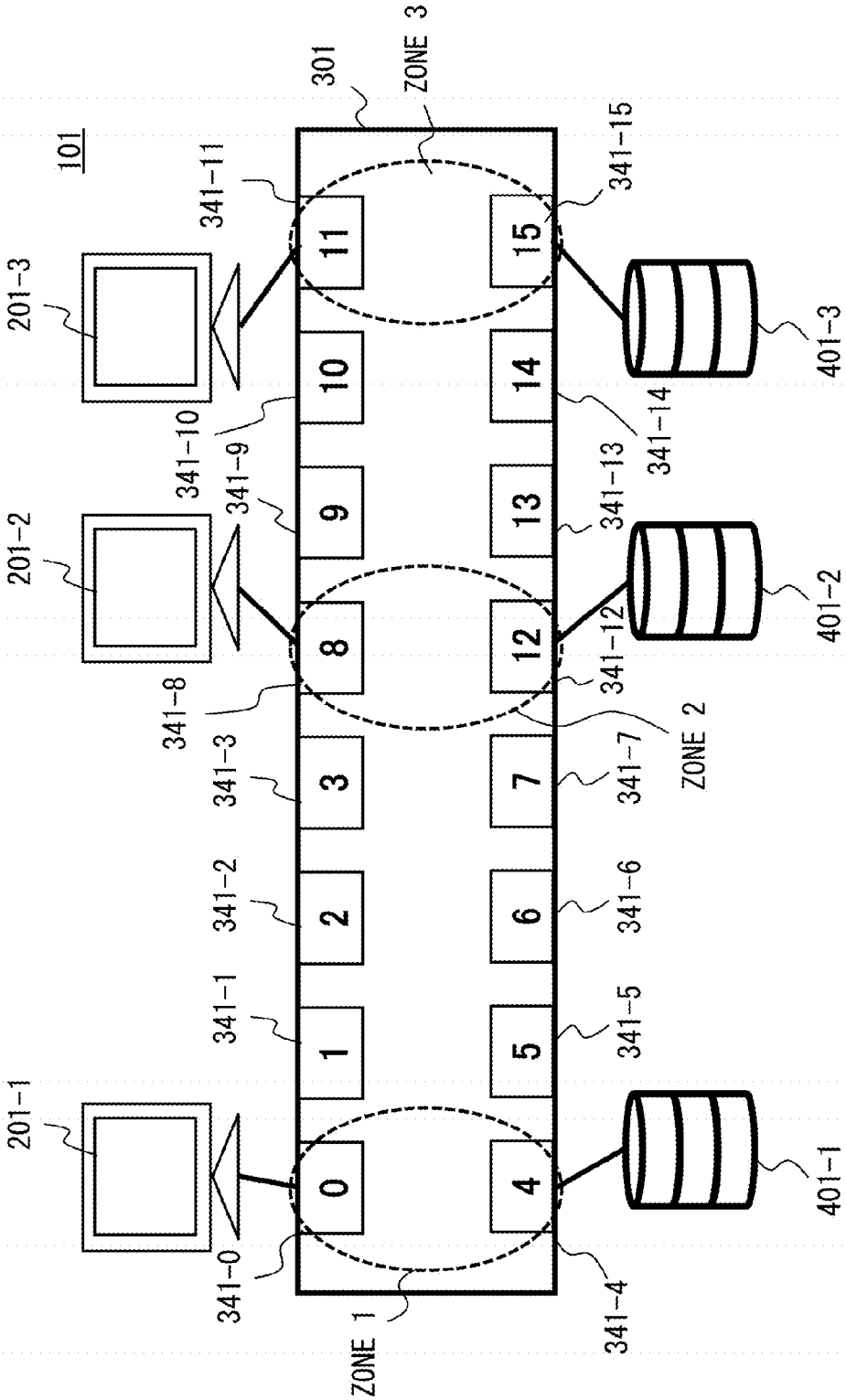

101
301
ZONE 3
ZONE 2
ZONE 1
201-1
201-2
201-3
401-1
401-2
401-3
341-0
341-1
341-2
341-3
341-4
341-5
341-6
341-7
341-8
341-9
341-10
341-11
341-12
341-13
341-14
341-15
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 2

333

PORT	DEVICE NAME	DESTINATION PORT NAME	DEVICE TYPE	CONNECTION STATE
0	20:00:00:e0:8b:13:08:10	21:00:00:e0:8b:13:08:10	Initiator	Online
2	20:00:00:e0:8b:13:08:60	21:00:00:e0:8b:13:08:60	Target	Online
3	20:00:00:e0:8b:13:08:10	21:00:00:e0:8b:13:08:20	Initiator	Online

FIG. 3

334

CONFIGURATION NAME	ZONE NAME	MEMBER NAME
Config1	Zone1	10:00
Config1	Zone1	10:01
Config1	Zone1	10:02
Config2	Zone2	10:11
Config2	Zone2	20:11

FIG. 4

335

PORT	ZONE NAME	DEVICE TYPE	CONNECTION STATE	POWER STATE
0	Zone1	Initiator	Online	On
1	(Null)	(Null)	Offline	Off
2	Zone1	Target	Online	On
3	(Null)	Initiator	Offline	Saving

FIG. 5

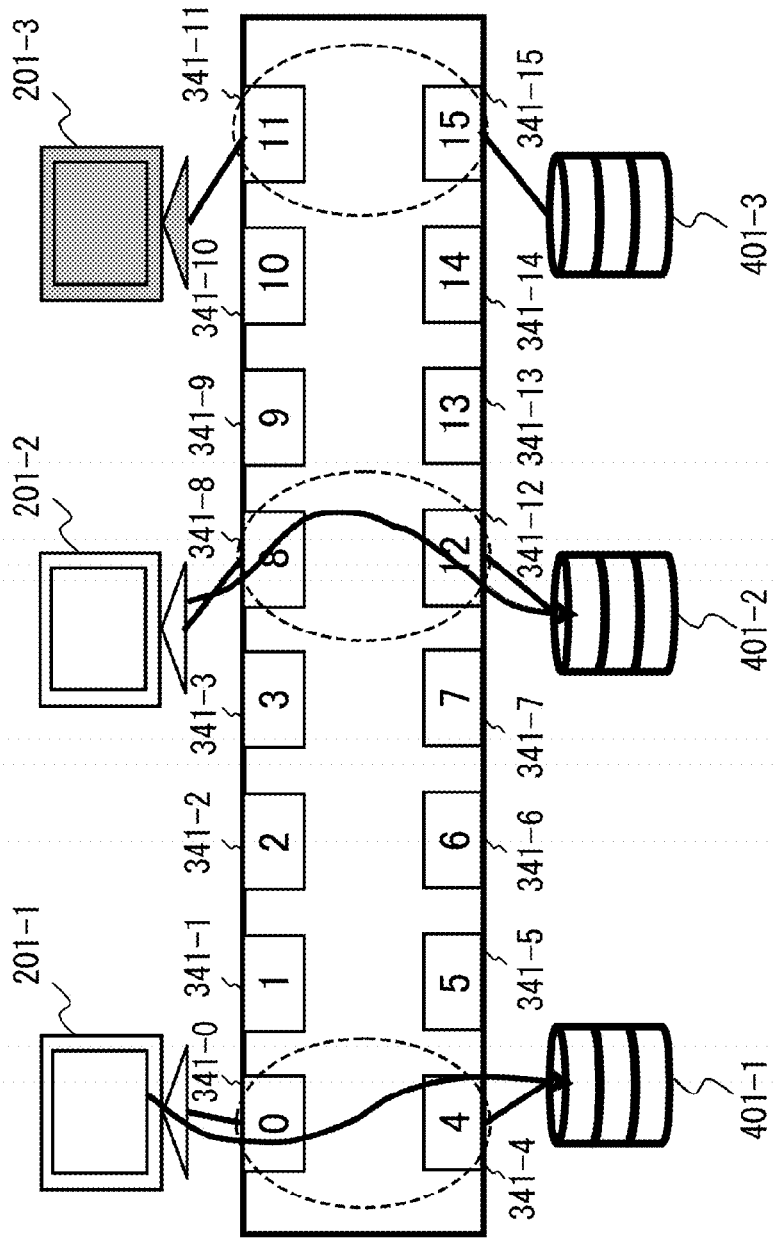

201-1
201-2
201-3
401-1
401-2
401-3
341-0
341-1
341-2
341-3
341-4
341-5
341-6
341-7
341-8
341-9
341-10
341-11
341-12
341-13
341-14
341-15
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 6

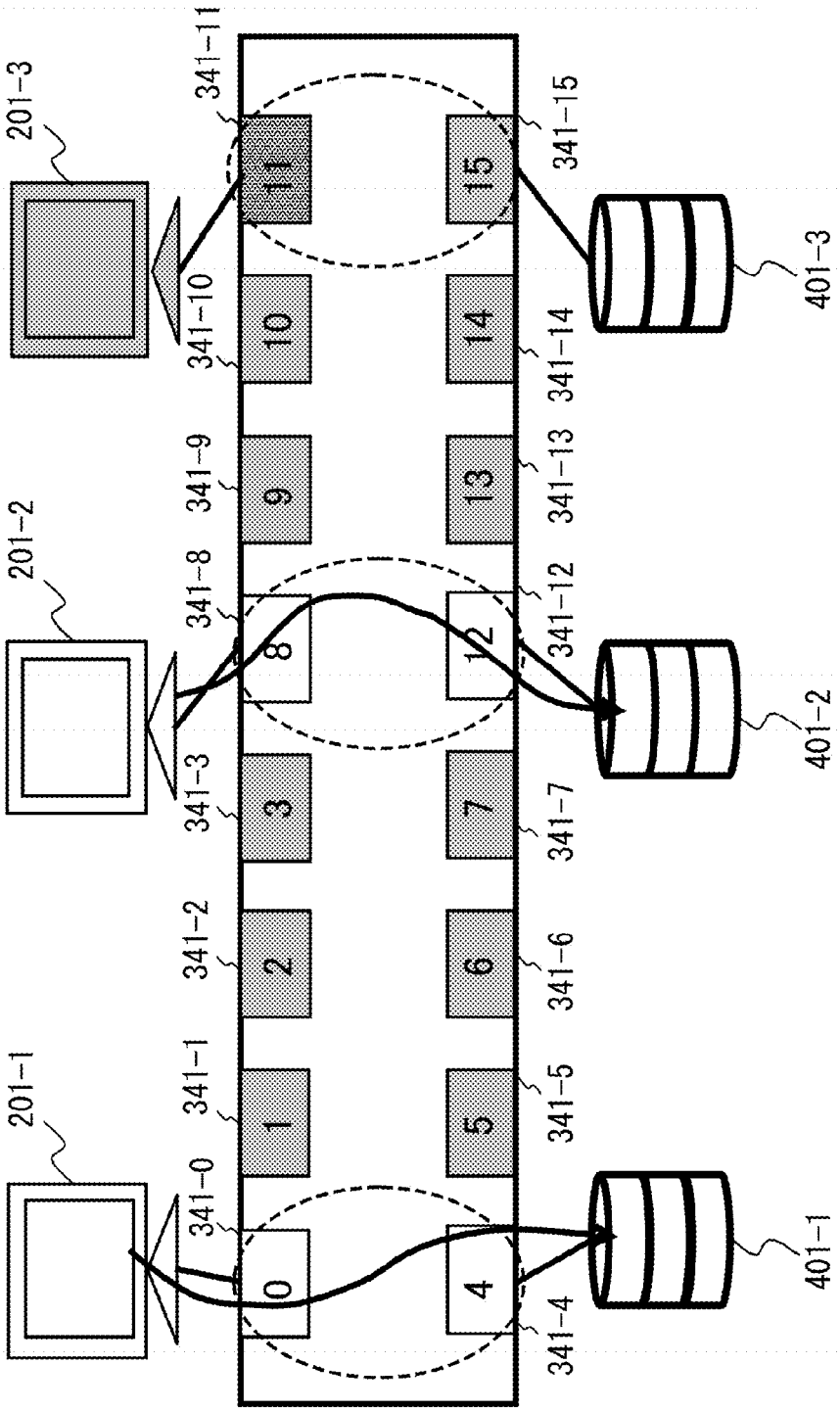

201-1
201-2
201-3
401-1
401-2
401-3
341-0
341-1
341-2
341-3
341-4
341-5
341-6
341-7
341-8
341-9
341-10
341-11
341-12
341-13
341-14
341-15
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 7

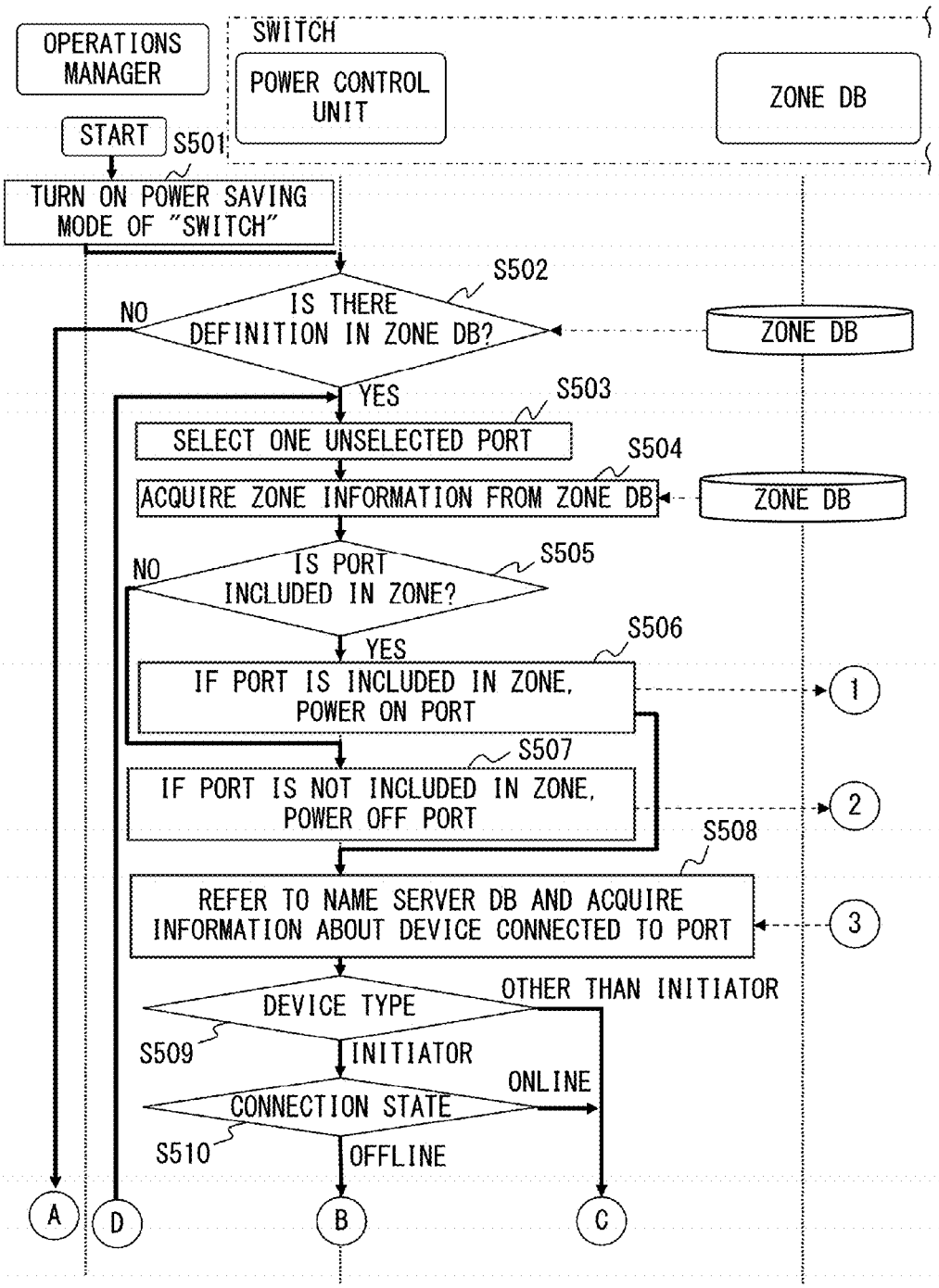

OPERATIONS MANAGER
SWITCH
POWER CONTROL UNIT
ZONE DB
START
S501
TURN ON POWER SAVING MODE OF "SWITCH"
S502
IS THERE DEFINITION IN ZONE DB?
NO
YES
ZONE DB
S503
SELECT ONE UNSELECTED PORT
S504
ACQUIRE ZONE INFORMATION FROM ZONE DB
ZONE DB
S505
IS PORT INCLUDED IN ZONE?
NO
YES
S506
IF PORT IS INCLUDED IN ZONE, POWER ON PORT
1
S507
IF PORT IS NOT INCLUDED IN ZONE, POWER OFF PORT
2
S508
REFER TO NAME SERVER DB AND ACQUIRE INFORMATION ABOUT DEVICE CONNECTED TO PORT
3
DEVICE TYPE
OTHER THAN INITIATOR
S509
INITIATOR
ONLINE
CONNECTION STATE
S510
OFFLINE
A
D
B
C

FIG. 8A

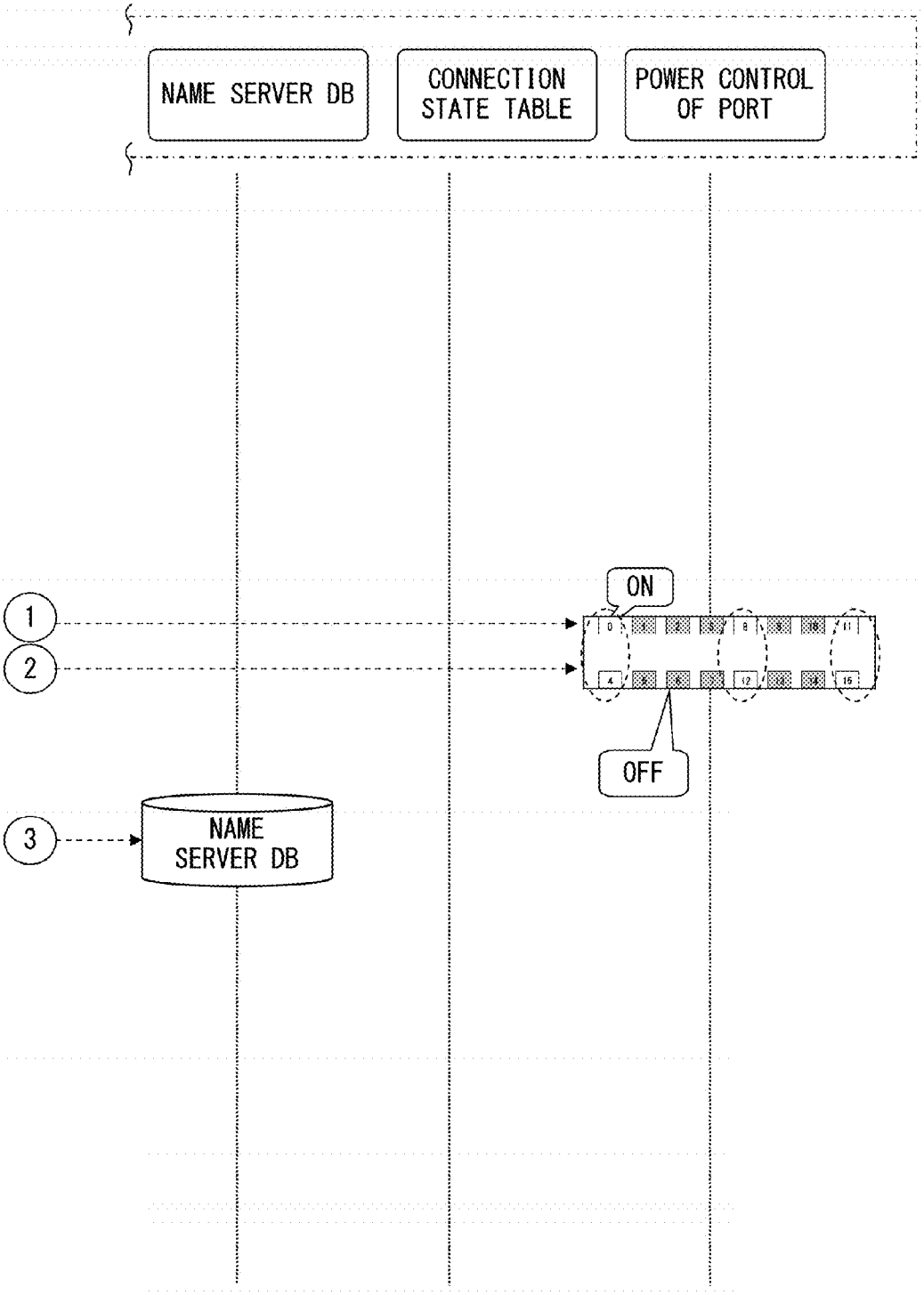

NAME SERVER DB
CONNECTION STATE TABLE
POWER CONTROL OF PORT
ON
OFF
1
2
3
NAME SERVER DB

FIG. 8B

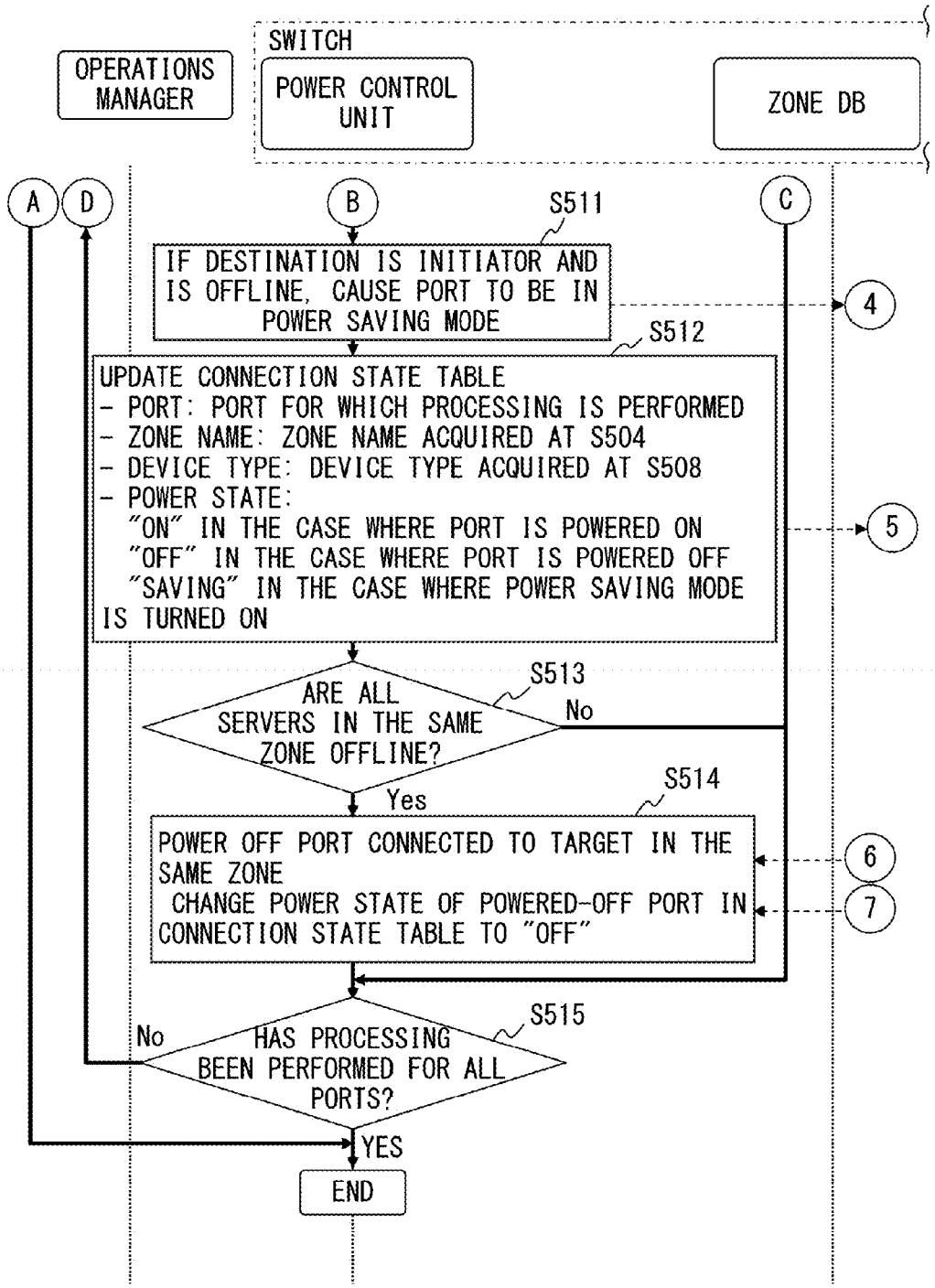

SWITCH
OPERATIONS MANAGER
POWER CONTROL UNIT
ZONE DB
A
D
B
C
S511
IF DESTINATION IS INITIATOR AND IS OFFLINE, CAUSE PORT TO BE IN POWER SAVING MODE
4
S512
UPDATE CONNECTION STATE TABLE
- PORT: PORT FOR WHICH PROCESSING IS PERFORMED
- ZONE NAME: ZONE NAME ACQUIRED AT S504
- DEVICE TYPE: DEVICE TYPE ACQUIRED AT S508
- POWER STATE:
"ON" IN THE CASE WHERE PORT IS POWERED ON
"OFF" IN THE CASE WHERE PORT IS POWERED OFF
"SAVING" IN THE CASE WHERE POWER SAVING MODE IS TURNED ON
5
S513
ARE ALL SERVERS IN THE SAME ZONE OFFLINE?
No
Yes
S514
POWER OFF PORT CONNECTED TO TARGET IN THE SAME ZONE
CHANGE POWER STATE OF POWERED-OFF PORT IN CONNECTION STATE TABLE TO "OFF"
6
7
S515
No
HAS PROCESSING BEEN PERFORMED FOR ALL PORTS?
YES
END

FIG. 8C

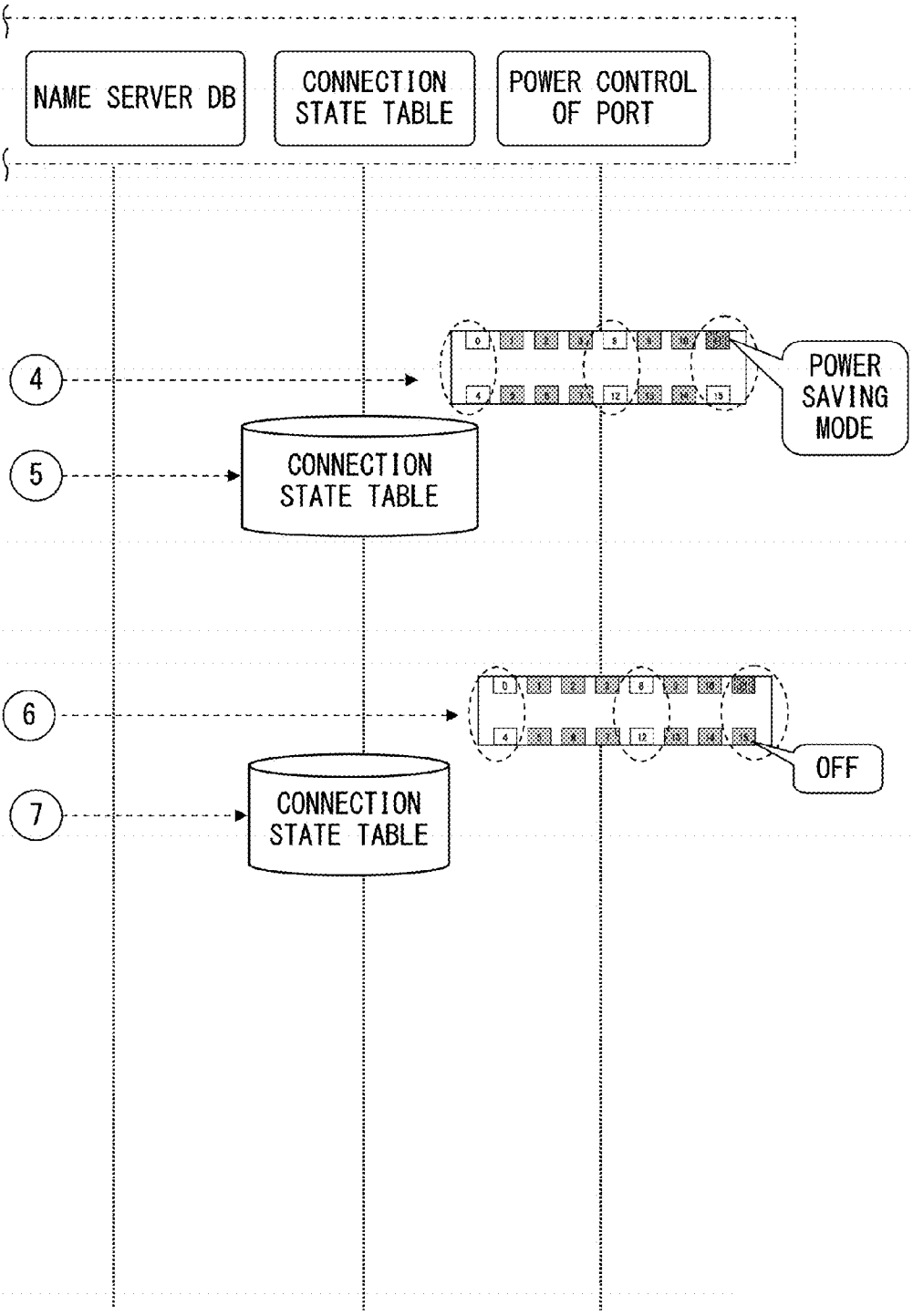

NAME SERVER DB
CONNECTION STATE TABLE
POWER CONTROL OF PORT
4
5
6
7
CONNECTION STATE TABLE
CONNECTION STATE TABLE
POWER SAVING MODE
OFF

FIG. 8D

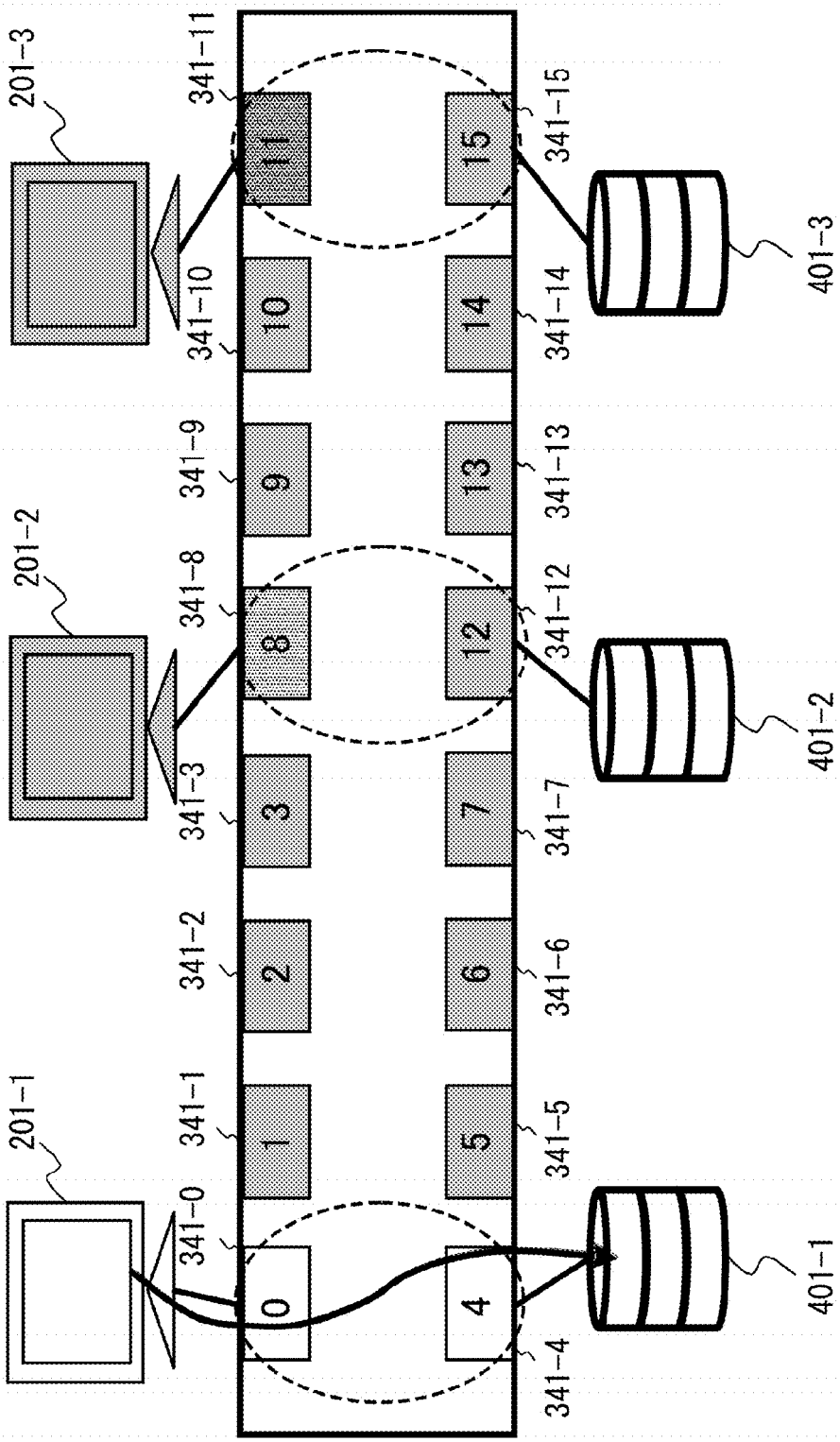

201-3
201-2
201-1
341-11
341-10
341-9
341-8
341-3
341-2
341-1
341-0
341-15
341-14
341-13
341-12
341-7
341-6
341-5
341-4
401-3
401-2
401-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

FIG. 9

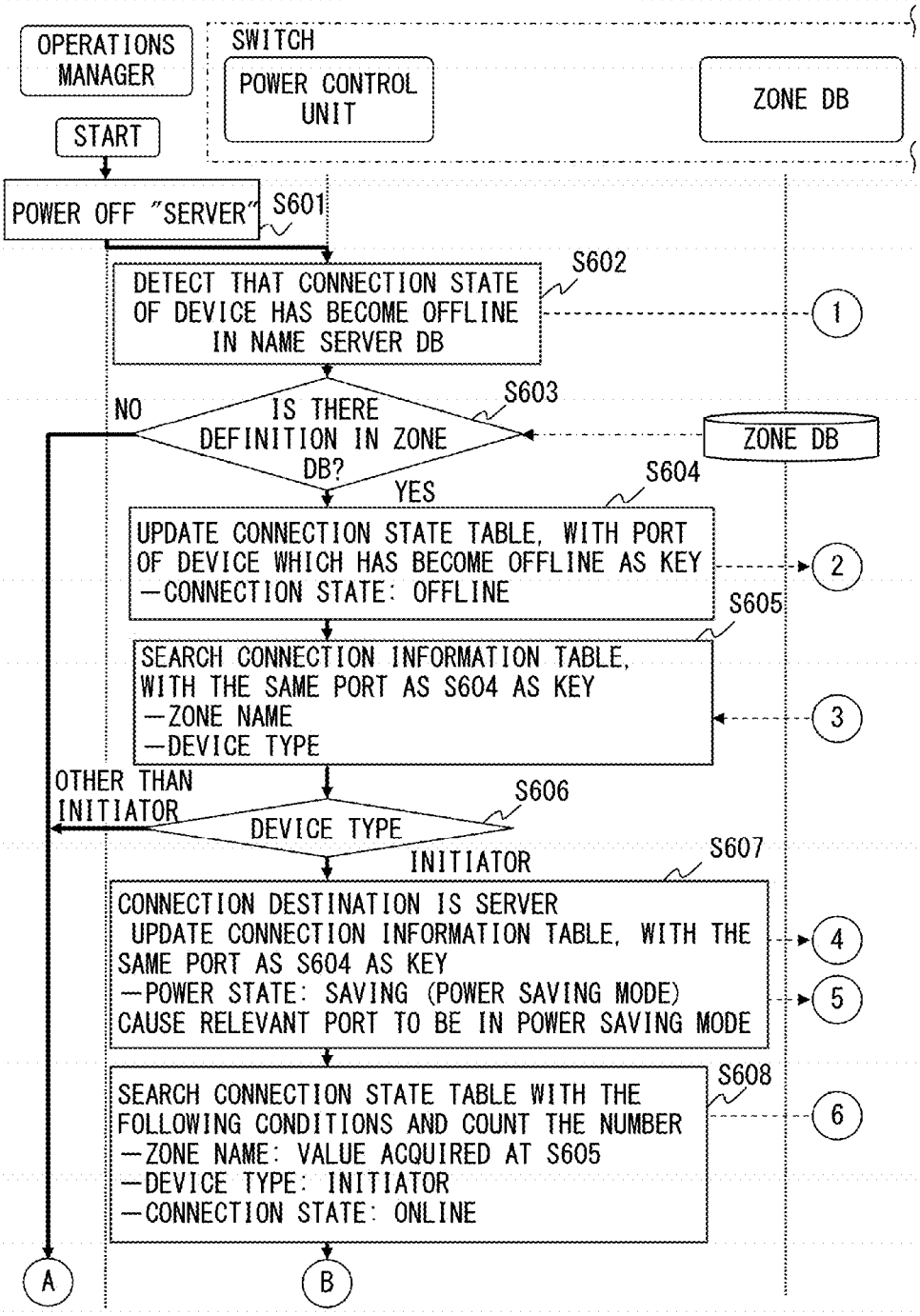

OPERATIONS MANAGER
SWITCH
POWER CONTROL UNIT
ZONE DB
START
POWER OFF "SERVER"
S601
S602
DETECT THAT CONNECTION STATE OF DEVICE HAS BECOME OFFLINE IN NAME SERVER DB
1
S603
NO
IS THERE DEFINITION IN ZONE DB?
ZONE DB
YES
S604
UPDATE CONNECTION STATE TABLE, WITH PORT OF DEVICE WHICH HAS BECOME OFFLINE AS KEY
—CONNECTION STATE: OFFLINE
2
S605
SEARCH CONNECTION INFORMATION TABLE, WITH THE SAME PORT AS S604 AS KEY
—ZONE NAME
—DEVICE TYPE
3
OTHER THAN INITIATOR
S606
DEVICE TYPE
INITIATOR
S607
CONNECTION DESTINATION IS SERVER
UPDATE CONNECTION INFORMATION TABLE, WITH THE SAME PORT AS S604 AS KEY
—POWER STATE: SAVING (POWER SAVING MODE)
CAUSE RELEVANT PORT TO BE IN POWER SAVING MODE
4
5
S608
SEARCH CONNECTION STATE TABLE WITH THE FOLLOWING CONDITIONS AND COUNT THE NUMBER
—ZONE NAME: VALUE ACQUIRED AT S605
—DEVICE TYPE: INITIATOR
—CONNECTION STATE: ONLINE
6
A
B

FIG. 10A

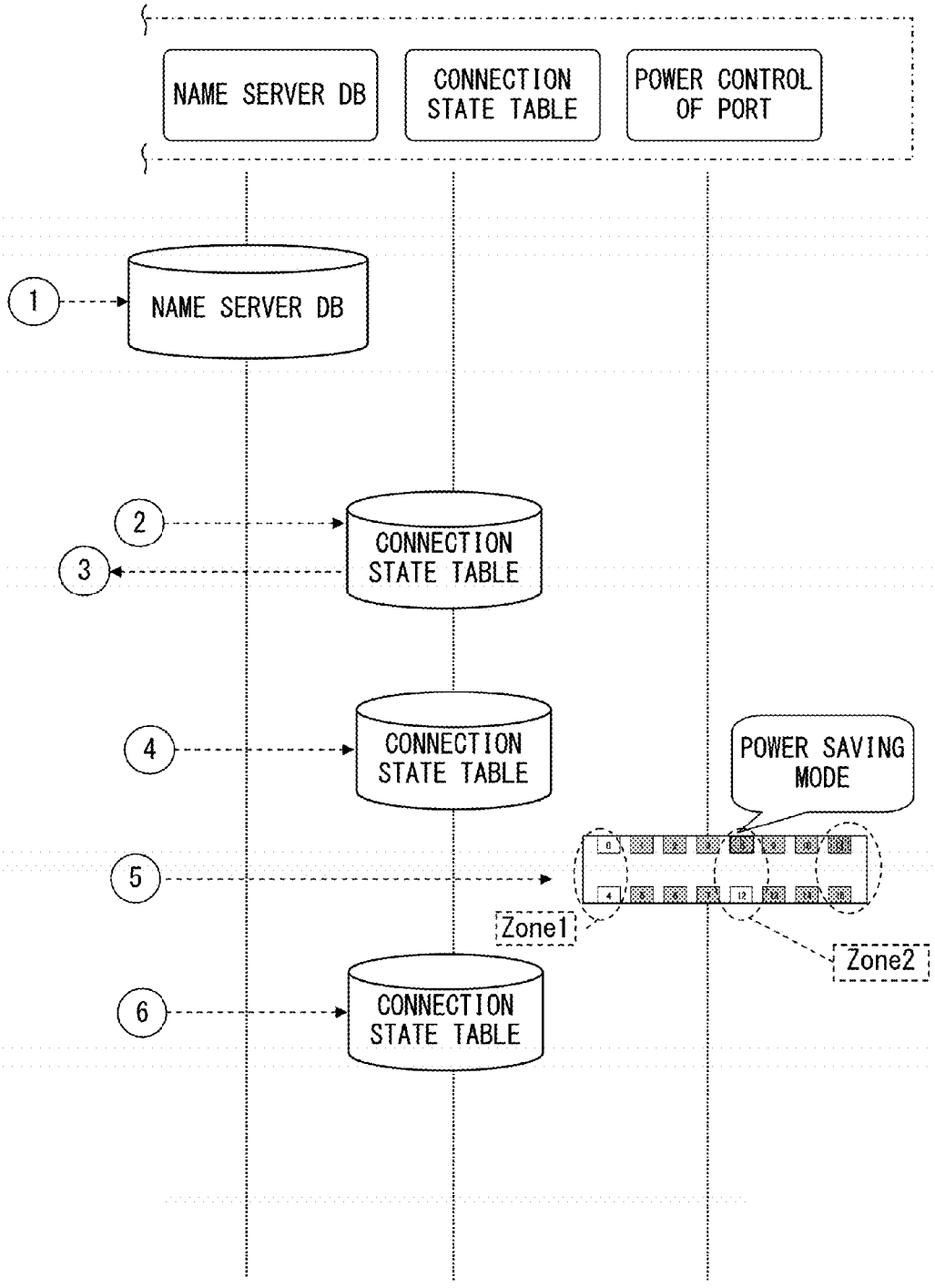

NAME SERVER DB
CONNECTION STATE TABLE
POWER CONTROL OF PORT
1
NAME SERVER DB
2
3
CONNECTION STATE TABLE
4
CONNECTION STATE TABLE
POWER SAVING MODE
5
Zone1
Zone2
6
CONNECTION STATE TABLE

FIG. 10B

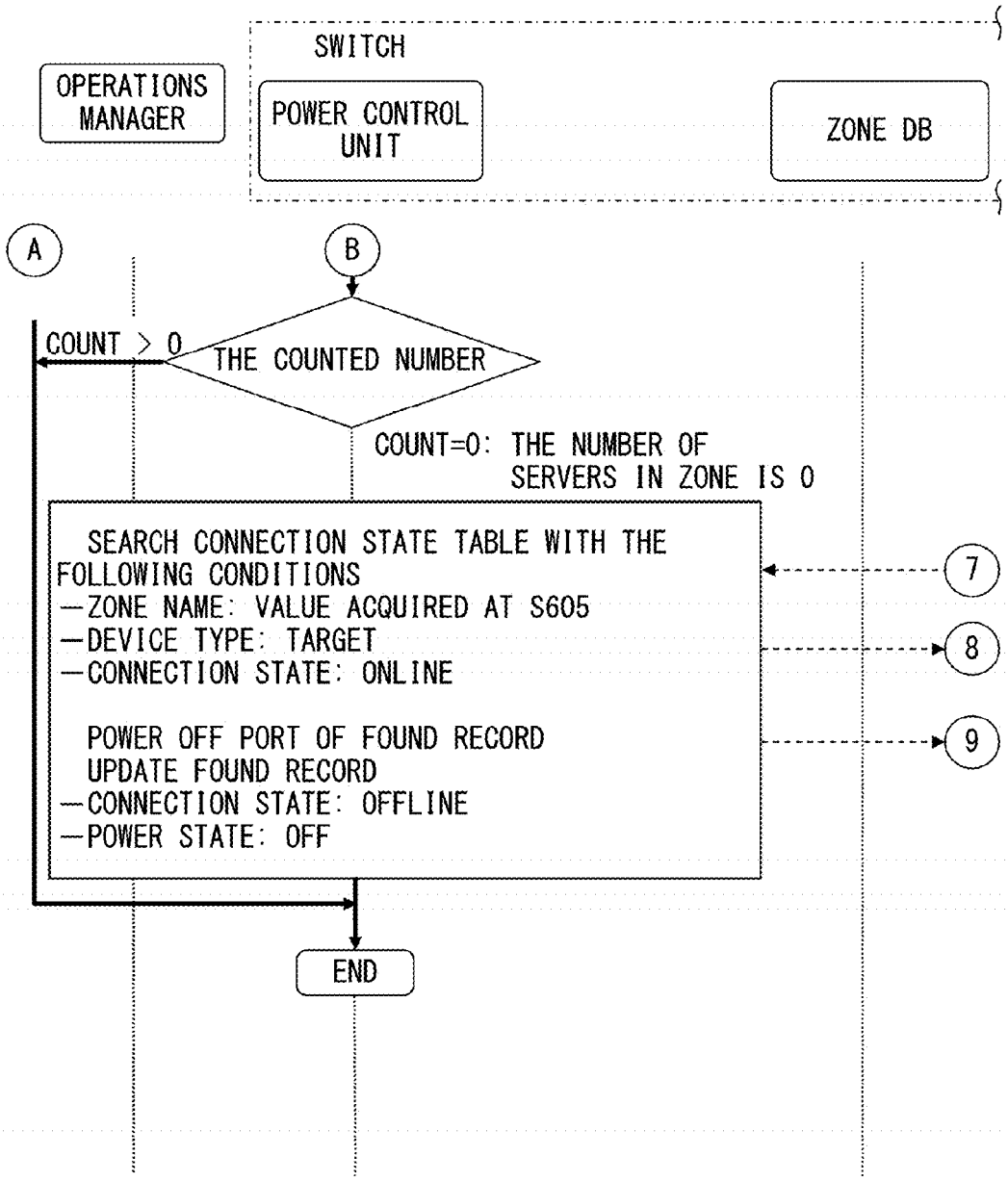

SWITCH
OPERATIONS MANAGER
POWER CONTROL UNIT
ZONE DB
A
B
COUNT > 0
THE COUNTED NUMBER
COUNT=0: THE NUMBER OF SERVERS IN ZONE IS 0
SEARCH CONNECTION STATE TABLE WITH THE FOLLOWING CONDITIONS
—ZONE NAME: VALUE ACQUIRED AT S605
—DEVICE TYPE: TARGET
—CONNECTION STATE: ONLINE
POWER OFF PORT OF FOUND RECORD
UPDATE FOUND RECORD
—CONNECTION STATE: OFFLINE
—POWER STATE: OFF
7
8
9
END

FIG. 10C

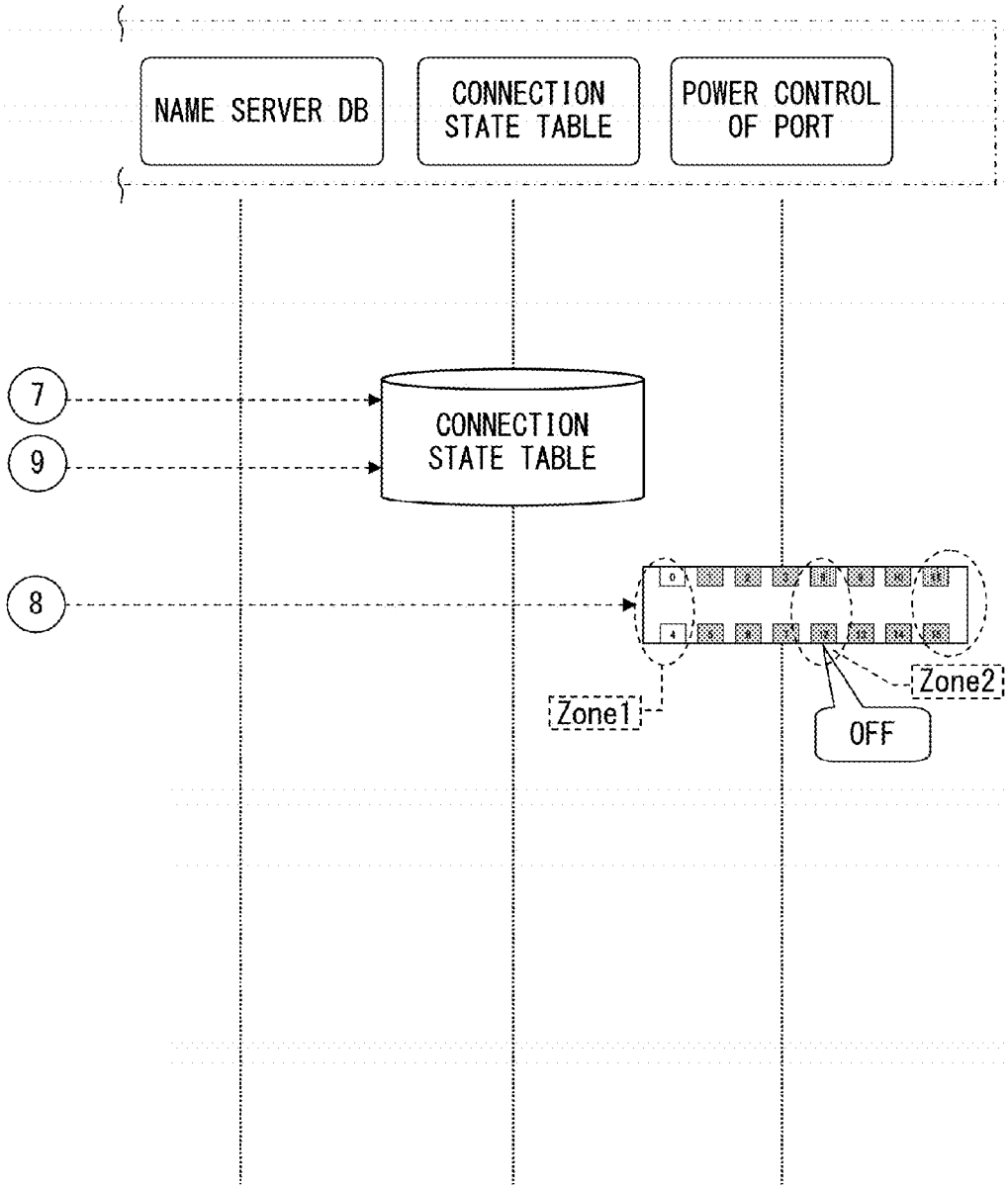
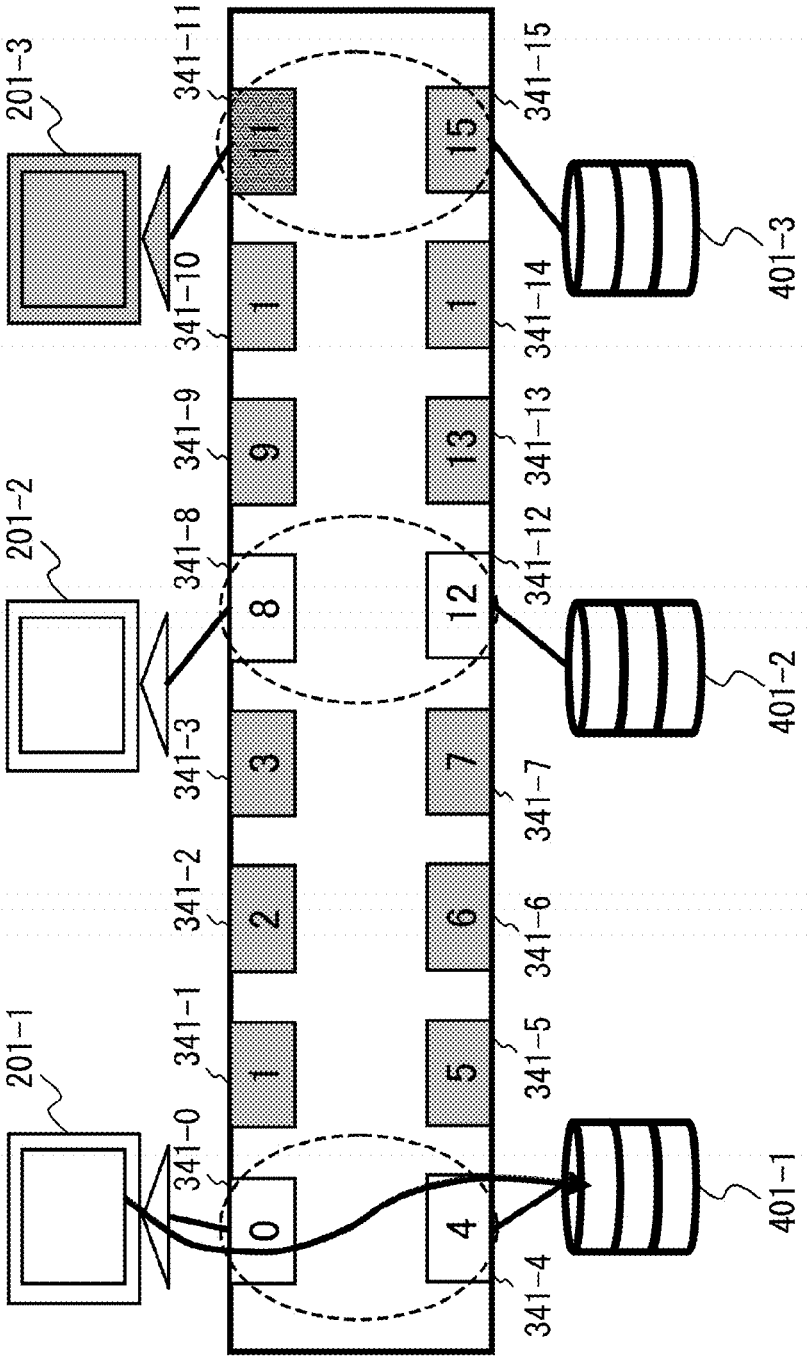

NAME SERVER DB
CONNECTION STATE TABLE
POWER CONTROL OF PORT
7
9
CONNECTION STATE TABLE
8
Zone1
Zone2
OFF

FIG. 10D


201-1
201-2
201-3
401-1
401-2
401-3
341-0
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341-4
341-5
341-6
341-7
341-8
341-9
341-10
341-11
341-12
341-13
341-14
341-15
0
1
2
3
4
5
6
7
8
9
1
11
12
13
1
15

FIG. 11

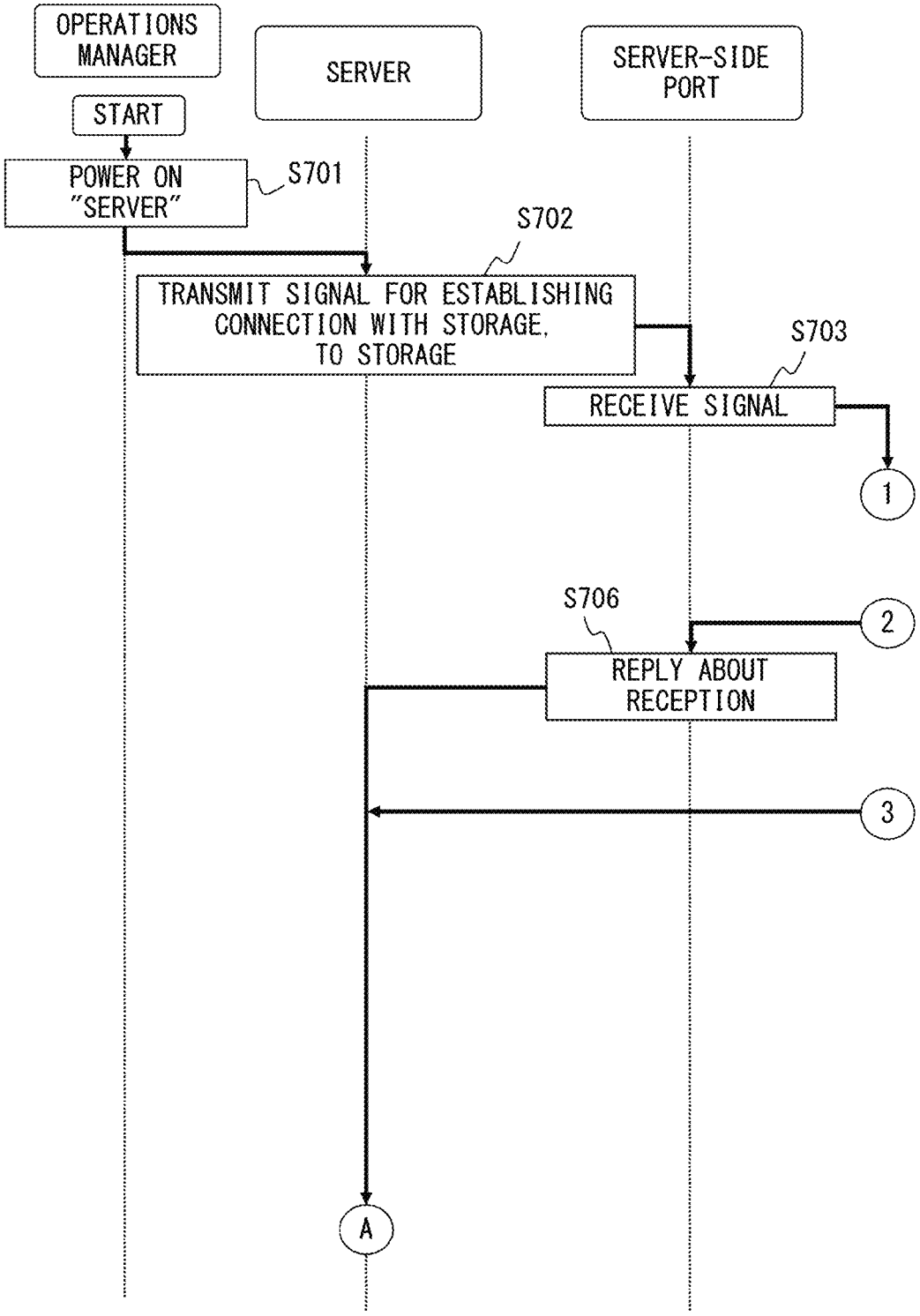
OPERATIONS MANAGER
SERVER
SERVER-SIDE PORT
START
POWER ON "SERVER"
S701
S702
TRANSMIT SIGNAL FOR ESTABLISHING CONNECTION WITH STORAGE, TO STORAGE
S703
RECEIVE SIGNAL
1
S706
2
REPLY ABOUT RECEPTION
3
A

FIG. 12A

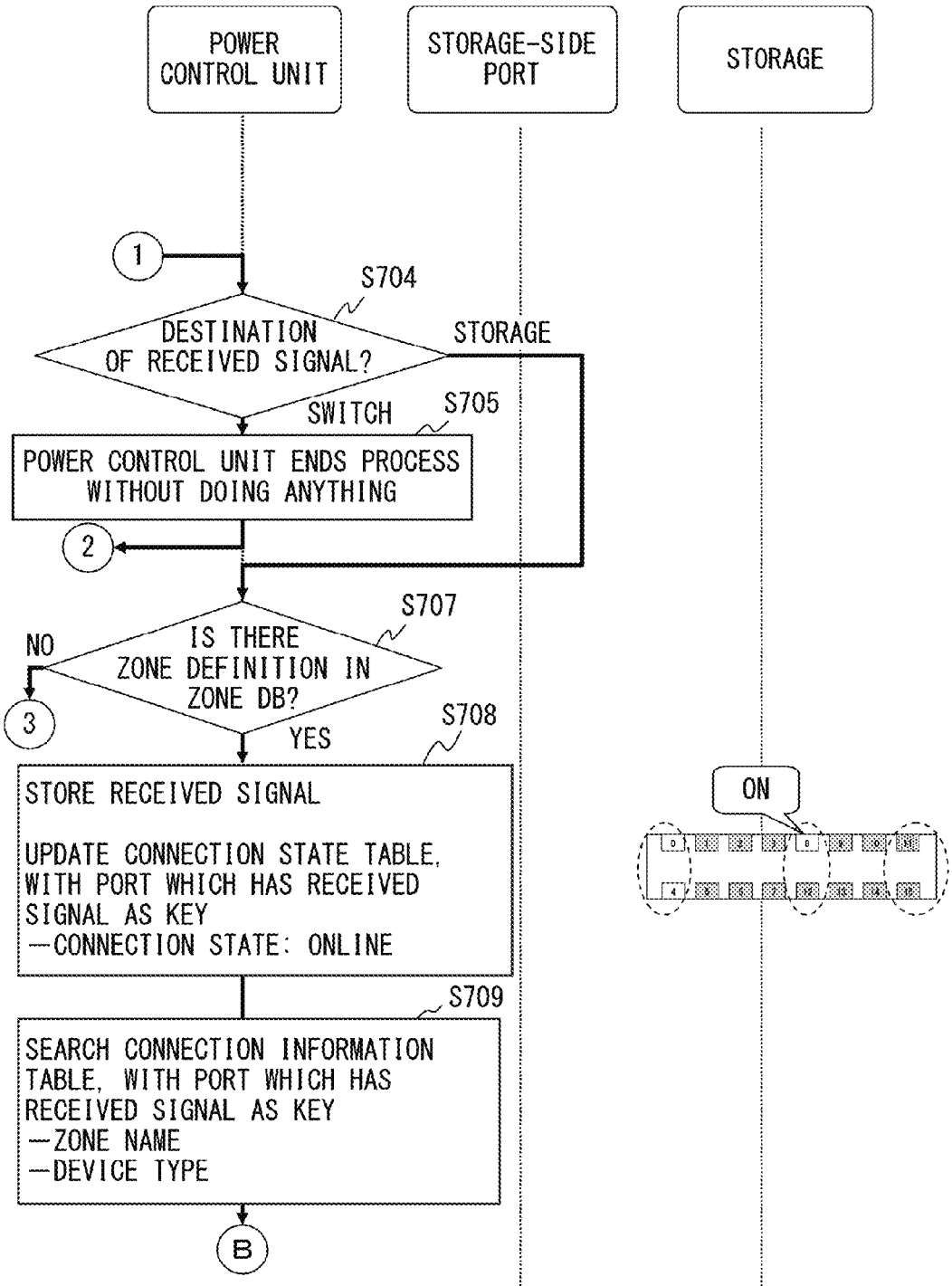
POWER CONTROL UNIT
STORAGE-SIDE PORT
STORAGE
1
S704
DESTINATION OF RECEIVED SIGNAL?
STORAGE
SWITCH
S705
POWER CONTROL UNIT ENDS PROCESS WITHOUT DOING ANYTHING
2
S707
NO
IS THERE ZONE DEFINITION IN ZONE DB?
3
YES
S708
STORE RECEIVED SIGNAL
UPDATE CONNECTION STATE TABLE, WITH PORT WHICH HAS RECEIVED SIGNAL AS KEY
—CONNECTION STATE: ONLINE
S709
SEARCH CONNECTION INFORMATION TABLE, WITH PORT WHICH HAS RECEIVED SIGNAL AS KEY
—ZONE NAME
—DEVICE TYPE
B
ON

FIG. 12B

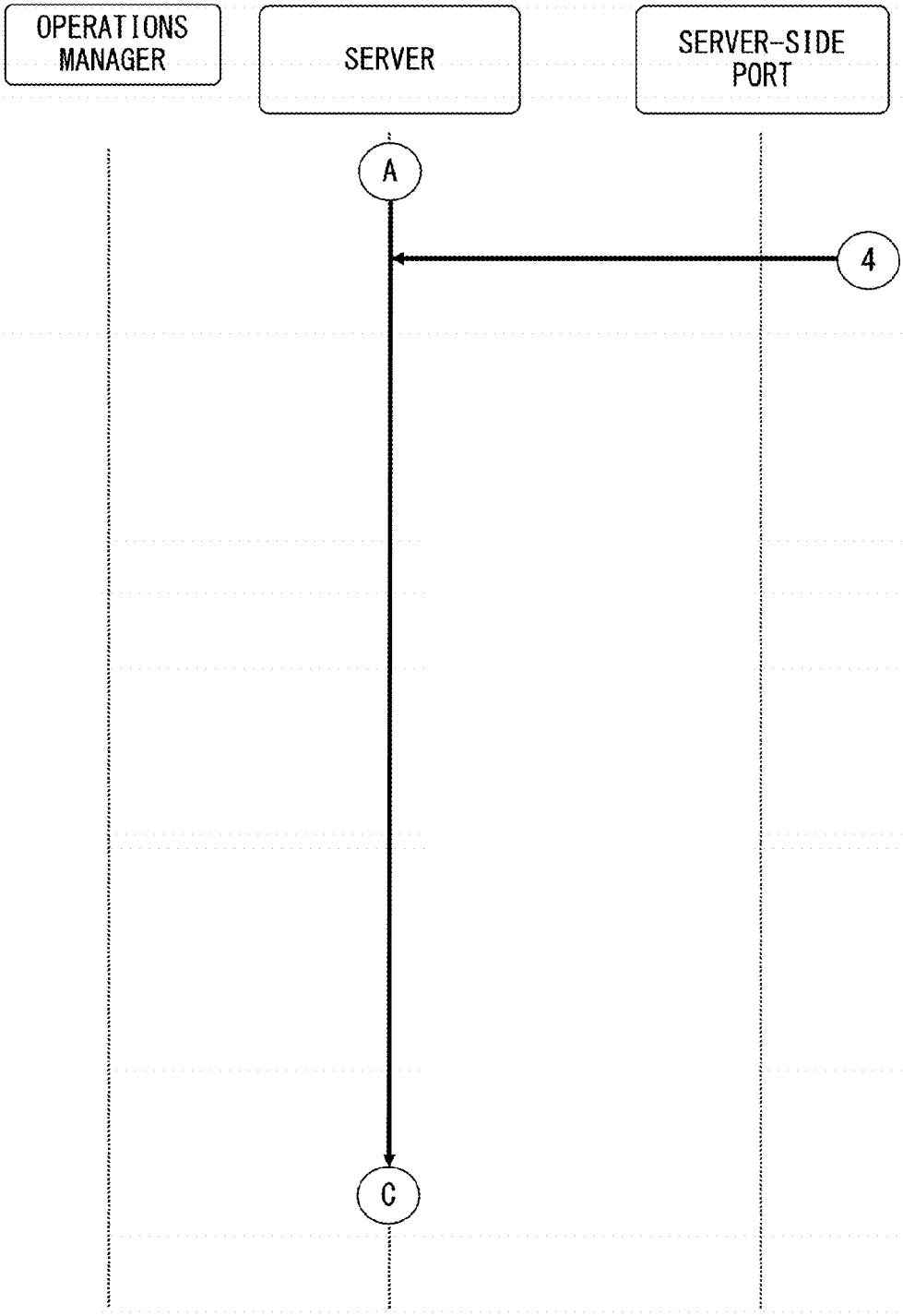

FIG. 12C

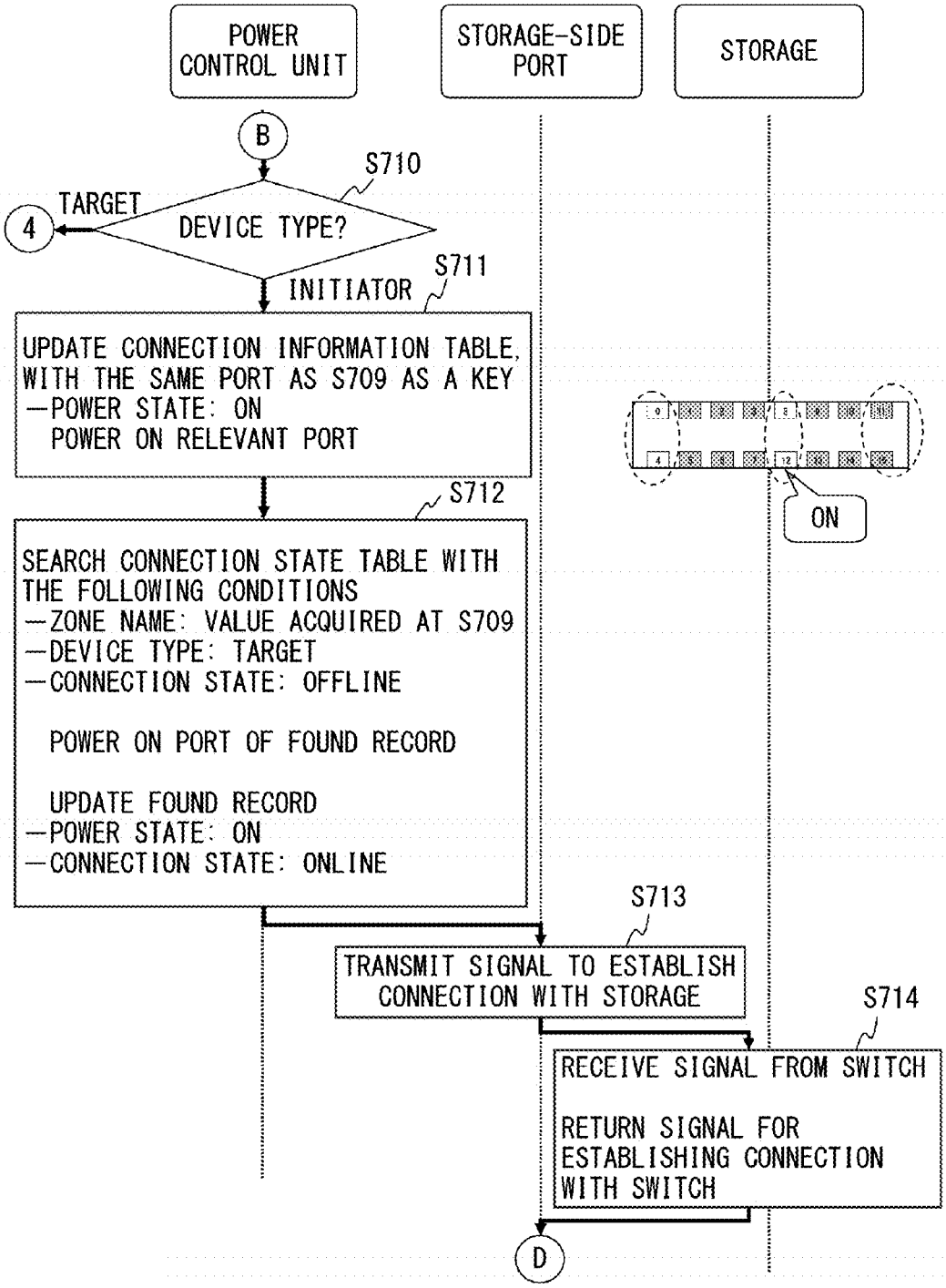
POWER CONTROL UNIT
STORAGE-SIDE PORT
STORAGE
B
S710
DEVICE TYPE?
TARGET
4
INITIATOR
S711
UPDATE CONNECTION INFORMATION TABLE, WITH THE SAME PORT AS S709 AS A KEY
—POWER STATE: ON
POWER ON RELEVANT PORT
S712
SEARCH CONNECTION STATE TABLE WITH THE FOLLOWING CONDITIONS
—ZONE NAME: VALUE ACQUIRED AT S709
—DEVICE TYPE: TARGET
—CONNECTION STATE: OFFLINE
POWER ON PORT OF FOUND RECORD
UPDATE FOUND RECORD
—POWER STATE: ON
—CONNECTION STATE: ONLINE
ON
S713
TRANSMIT SIGNAL TO ESTABLISH CONNECTION WITH STORAGE
S714
RECEIVE SIGNAL FROM SWITCH
RETURN SIGNAL FOR ESTABLISHING CONNECTION WITH SWITCH
D

FIG. 12D

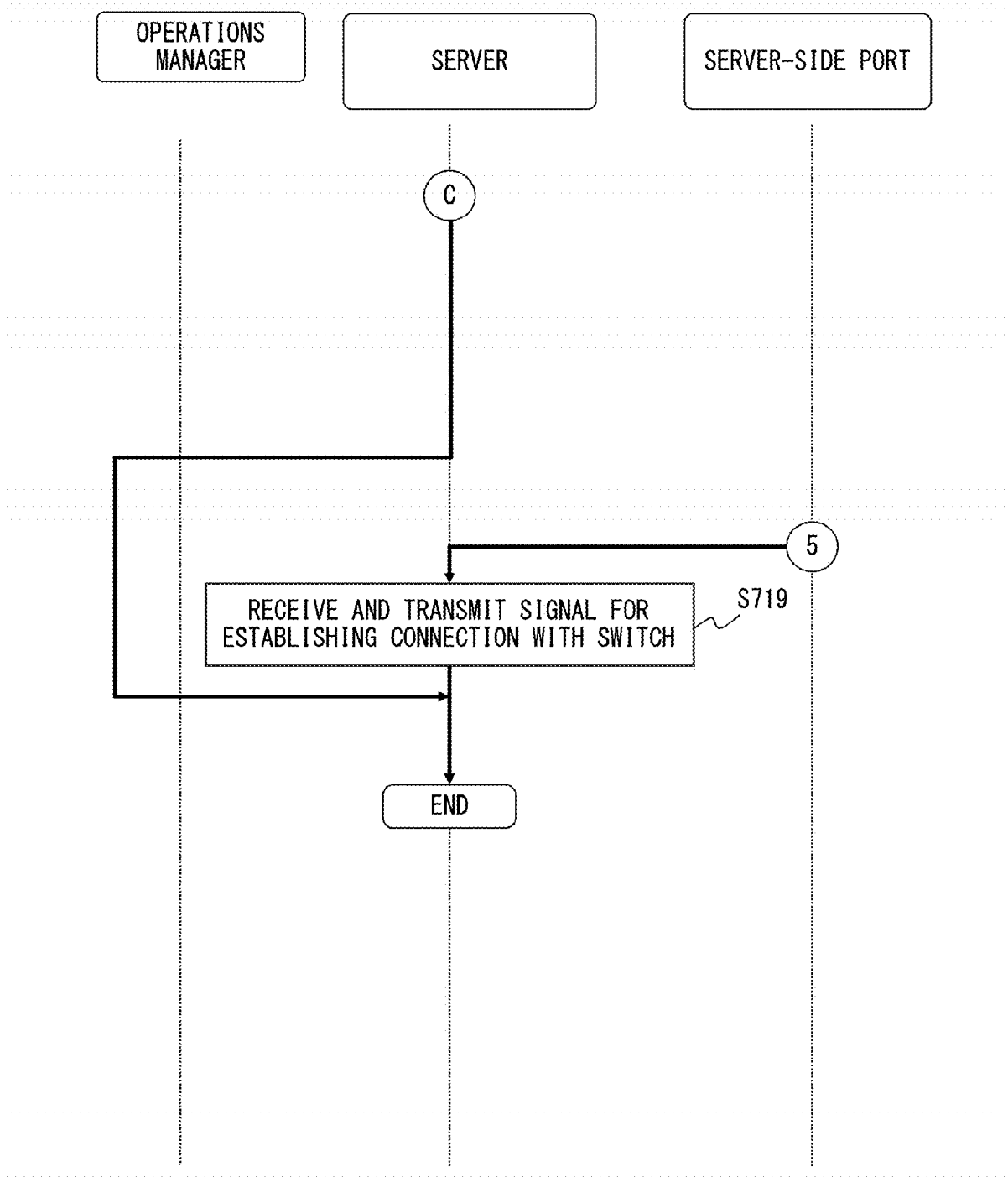
OPERATIONS MANAGER
SERVER
SERVER-SIDE PORT
C
5
RECEIVE AND TRANSMIT SIGNAL FOR ESTABLISHING CONNECTION WITH SWITCH
S719
END

FIG. 12E

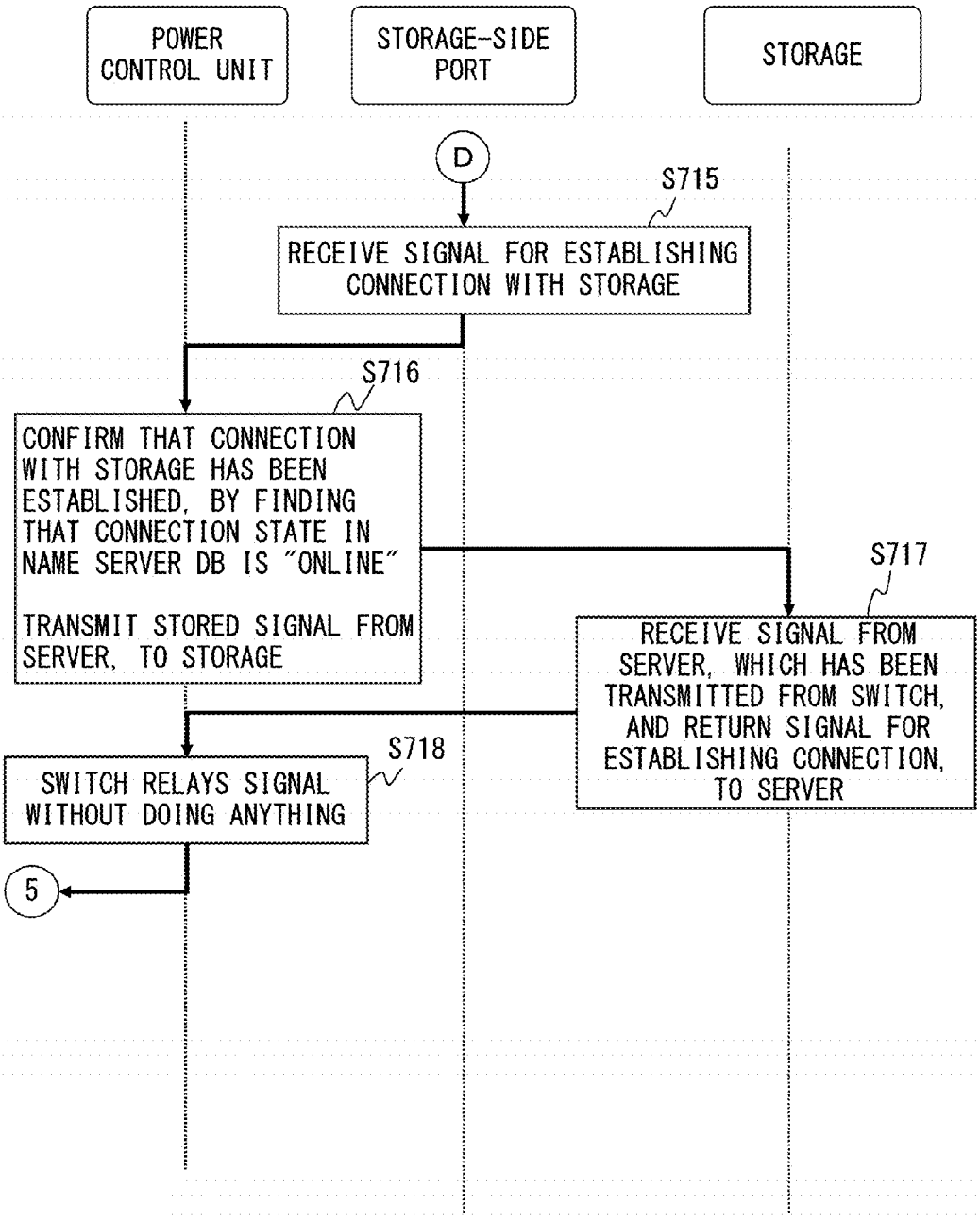
POWER CONTROL UNIT
STORAGE-SIDE PORT
STORAGE
D
S715
RECEIVE SIGNAL FOR ESTABLISHING CONNECTION WITH STORAGE
S716
CONFIRM THAT CONNECTION WITH STORAGE HAS BEEN ESTABLISHED, BY FINDING THAT CONNECTION STATE IN NAME SERVER DB IS "ONLINE"
TRANSMIT STORED SIGNAL FROM SERVER, TO STORAGE
S717
RECEIVE SIGNAL FROM SERVER, WHICH HAS BEEN TRANSMITTED FROM SWITCH, AND RETURN SIGNAL FOR ESTABLISHING CONNECTION, TO SERVER
S718
SWITCH RELAYS SIGNAL WITHOUT DOING ANYTHING
5

FIG. 12F

SWITCH AND CONTROL METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2013-136352, filed on Jun. 28, 2013, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to a switch and a control method.

BACKGROUND

Currently, storage area networks (SANs) in which a server and a storage are connected via a high-speed network are used.

In the SAN, a fiber channel switch is used as a device connecting the server and the storage.

A conventional fiber channel switch is not equipped with a power saving function, and its ports are continuously being powered on even if there is an unused port. Therefore, there is a problem that power is wastefully consumed (Japanese Patent Laid-Open No. 2009-282859 and Japanese Patent Laid-Open No. 2008-41050).

SUMMARY

According to an aspect of the invention, a switch is connected to external devices and is provided with a plurality of ports connected to the external devices, a storage unit and a processor.

The storage unit stores a zone database indicating a group in which each of the plurality of ports is included.

The processor performs power control the plurality of ports and powers off a port which is not included in any group among the plurality of ports, on the basis of the zone database.

The processor permits communication between ports included in the same group, on the basis of the zone database.

A switch of another embodiment is connected to external devices and is provided with a plurality of ports connected to the external devices, a storage unit and a processor.

The storage unit stores a zone database indicating a group in which each of the plurality of ports is included, and a connection state table in which the group in which each of the plurality of ports is included, a type of the external device connected to each of the plurality of ports, and a state of connection with the external device are written.

The processor performs power control of the plurality of ports.

The processor permits communication between ports included in the same group, on the basis of the zone database, and continuously transmits a signal from a port when the port is being powered on.

The processor detects that the external device has been powered off, refers to the connection state table, and, when the type of the external device that has been powered off is an information processing device, stops transmission of the signal from a port connected to the information processing device that has been powered off.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a configuration diagram of a system according to an embodiment;

FIG. **2** is a diagram illustrating zones of the system according to the embodiment;

FIG. **3** is a diagram illustrating an example of a name server DB;

FIG. **4** is a diagram illustrating an example of a zone DB;

FIG. **5** is a diagram illustrating an example of a connection state table;

FIG. **6** is a diagram illustrating the system when a power saving mode of a switch is off;

FIG. **7** is a diagram illustrating the system when the power saving mode of the switch is turned on;

FIG. **8**A is a sequence diagram illustrating a process of the system when the power saving mode is turned on;

FIG. **8**B is the sequence diagram illustrating the process of the system when the power saving mode is turned on;

FIG. **8**C is the sequence diagram illustrating the process of the system when the power saving mode is turned on;

FIG. **8**D is the sequence diagram illustrating the process of the system when the power saving mode is turned on;

FIG. **9** is a diagram illustrating the system when a server is powered off;

FIG. **10**A is a sequence diagram illustrating a process of the system when the server is powered off;

FIG. **10**B is the sequence diagram illustrating the process of the system when the server is powered off;

FIG. **10**C is the sequence diagram illustrating the process of the system when the server is powered off;

FIG. **10**D is the sequence diagram illustrating the process of the system when the server is powered off;

FIG. **11** is a diagram illustrating the system when the server is powered on;

FIG. **12**A is a sequence diagram illustrating a process of the system when the server is powered on;

FIG. **12**B is the sequence diagram illustrating the process of the system when the server is powered on;

FIG. **12**C is the sequence diagram illustrating the process of the system when the server is powered on;

FIG. **12**D is the sequence diagram illustrating the process of the system when the server is powered on;

FIG. **12**E is the sequence diagram illustrating the process of the system when the server is powered on; and

FIG. **12**F is the sequence diagram illustrating the process of the system when the server is powered on.

DESCRIPTION OF EMBODIMENTS

An embodiment will be described below with reference to drawings.

FIG. **1** is a configuration diagram of a system according to the embodiment.

A system **101** includes servers **201**-*i* (i=1 to 3), a fiber channel switch **301** (hereinafter referred to as the switch **301**), and storages **401**-*j* (j=1 to 3).

The servers **201** and the switch **301**, and the switch **301** and the storages **401** are connected via fiber channels,

respectively. In FIG. **1**, the servers **201**, the switch **301** and the storages **401** constitute a SAN.

The server **201** transmits a reading request to the storage **401** and reads out data from the storage **401**. The server **201** also transmits a writing request and data to the storage **401** and writes the data into the storage **401**.

The server **201** is an example of an information processing device.

The switch **301** performs data transfer between the server **201** and the storage **401**.

The switch **301** includes a central processing unit (CPU) **311**, a volatile memory **321**, a nonvolatile memory **331**, and ports **341**-*k* (k=0 to 15).

The CPU **311** is a processor (a processing unit) which performs various processes.

The CPU **311** includes a switch control unit **312**.

The switch control unit **312** performs a process of relaying data and control of the switch **301**. The switch control unit **312** performs control so as to permit communication (I/O traffic) only within the same group, on the basis of a zone DB **334**.

The switch control unit **312** performs reading from and writing to a name server database (DB) **333**, the zone DB **334** and a connection state table **335**.

The switch control unit **312** is realized by a program for controlling the switch **301** being read out into the volatile memory **321** and the CPU **311** executing the program on the volatile memory **321**.

The switch control unit **312** includes a power control unit **313**.

The power control unit **313** controls power on/off of the ports **341** on the basis of the name server DB **333**, the zone DB **334** and the connection state table **335**.

The power control unit **313** powers on or off the ports **341** or causes the ports to be in the power saving mode.

Here, the power saving mode will be explained.

When a port **341** is being powered on, the switch control unit **312** continuously transmits an electric signal from the port **341**. Even when a device is not connected to the port **341**, the port **341** continuously transmits an electric signal. This is for, when a device is connected to the port **341**, notifying the device of the connection.

The power saving mode is a state in which the switch control unit **312** stops transmission of an electric signal from the port **341** in response to an instruction from the power control unit **313**, and the port **341** performs only reception of a signal (though the port **341** continues to be powered on). For example, if a port connected to a server is also powered off when the server is being powered off, the port cannot receive a notification from the server even when the server is powered on. Therefore, when the server is being powered off, the port **341** enters the power saving mode in which only signal reception is performed. In the power saving mode, since transmission of an electric signal is not performed, power consumption is reduced.

The power control unit **313** is realized by a power saving program **332** being read out into the volatile memory **321** and the CPU **311** executing the power saving program **332** on the volatile memory **321**.

The switch control unit **312** and the power control unit **313** can be also realized by hardware circuits such as a programmable logic device (PLD) and an application specific integrated circuit (ASIC).

The volatile memory **321** is a storage device which stores data, programs and the like used by the switch **301**. The volatile memory **321** is, for example, a random access memory (RAM).

The nonvolatile memory **331** is a storage device which stores data, programs and the like used by the switch **301**. The nonvolatile memory **331** is, for example, a flash memory.

The nonvolatile memory **331** stores the power saving program **332**, the name server DB **333**, the zone DB **334** and the connection state table **335**.

The power saving program **332** is a program which performs power control of the ports **341**.

The details of the name server DB **333**, the zone DB **334** and the connection state table **335** will be described later.

The port **341** is an interface which connects to an external device (a server **201** and a storage **401**) and performs data input/output (signal reception/transmission) with the external device.

An index number k for identifying a port is assigned to the port **341**-*k*. In drawings and the description of the specification, the port **341**-*k* may be referred to as the port k.

The switch **301** can power on/off the ports **341** individually.

In the embodiment, a port **341-0**, a port **341-8**, a port **341-11**, a port **341-4**, a port **341-12** and a port **341-15** are connected to a server **201-1**, a server **201-2**, a server **201-3**, a server **401-1**, a server **401-2** and a server **401-3**, respectively.

The storage **401** is a device which stores data. The storage **401** is, for example, a magnetic disk device (a hard disk drive (HDD)), a magnetic tape device, a disk array device provided with a plurality of HDDs or the like.

The switch **301** performs access control using zoning.

FIG. **2** is a diagram illustrating zones of the system according to the embodiment.

Zoning is to create definitions of grouping the index numbers of the ports **341** and grouping the ports **341** on the basis of the definitions. A defined group is called a zone.

The switch control unit **312** performs control so as to permit communication (I/O traffic) only within a group.

As shown in FIG. **2**, ports **0** and **4** are included in a zone **1**; ports **8** and **12** are included in a zone **2**; and ports **11** and **15** are included in a zone **3**.

Thereby, communication between the server **201-1** and the storage **401-1** is permitted. Each of communication between the server **201-2** and the storage **401-2** and communication between the server **201-3** and the storage **401-3** is also permitted.

FIG. **3** is a diagram illustrating an example of the name server DB.

In the name server DB **333**, information about devices (for example, the servers **201** and the storages **401**) connected to the switch **301** is written.

In the name server DB **333**, a port, a device name, a destination port name, a device type, and a connection state are written in association with one another.

The port is indicated by an index number assigned to a port **341** connected to a device.

The device name is a world wide name (WWN) of the device connected to the port **341**.

The destination port name is the WWN of the port of the device connected to the port **341**.

The device type indicates the type of the device connected to the port **341**. The device type is, for example, "Initiator" if the device is a server, "Target" if the device is a storage, and "Unknown" if the device type is unknown.

The connection state shows a connection state between the port **341** and the device. The connection state is "Online"

or "Offline". The connection state is "Online" if the device is being powered on. The connection state is "Offline" if the device is being powered off.

FIG. **4** is a diagram illustrating an example of the zone DB.

In the zone DB **334**, zoning setting information, that is, a zone definition showing which port is included in which zone is written.

In the zone DB **334**, a configuration name, a zone name, and a member name are written in association with one another.

The configuration name is a name given to a unit for which zone setting is enabled or disabled.

The zone name is the name of a zone.

The member name is information about a port included in the zone. The member name is a format of combination of a number (a node number) assigned to the switch **301** and the index number of a port **341**. For example, "10:2" indicates a port with an index number **2** of a switch with a node number **10**.

The zone DB **334** shown in FIG. **4** shows that ports with index numbers **0**, **1** and **2** of the switch with the node number **10** are included in Zone **1**, and that a port with an index number **11** of the switch with the node number **10** and a port with an index number **11** of a switch with a node number **20** are included in Zone **2**.

FIG. **5** is a diagram illustrating an example of the connection state table.

In the connection state table **335**, states of connections with devices connected to the switch **301** are written.

In the connection state table **335**, a port, a zone name, a device type, a connection state, and a power state are written in association with one another.

The port is indicated by an index number assigned to a port **341** connected to a device.

The zone name is the name of a zone.

The device type shows the type of the device connected to the port. The device type is, for example, "Null" if a device is not connected, "Initiator" if the device is a server, "Target" if the device is a storage, and "Switch" if the device is a switch.

The connection state shows a connection state between the port **341** and the device. The connection state is "Online" in the case of being connected to the device (that is the device is being powered on). The connection state is "Offline" in the case of not being connected to the device (that is the device is being powered off).

The power state shows the power state of the port **341**. The power state is "On" if the port is being powered on, "Off" if the port is being powered off, and "Saving" if the port is in the power saving mode.

The connection state table **335** shown in FIG. **5** shows that the port **0** is included in Zone **1**, connected to a server, online with the server and is being powered on. The connection state table **335** shown in FIG. **5** shows that the port **2** is included in Zone **1**, connected to a storage, online with the storage and is being powered on.

The connection state table **335** shown in FIG. **5** also shows that a device is not connected to the port **1**, and that the port **3** is in the power saving mode.

Next, description will be made on how power control of the ports **341** is performed for each transition of the state of the switch **301** and the servers **201**.

FIG. **6** is a diagram illustrating the system when the power saving mode of the switch is off.

In FIG. **6**, the servers **201-1** and **202-2** and the storages **401-1** to **401-3** are being powered on, and the server **201-3** is being powered off.

As described with reference to FIG. **2**, the ports **0** and **4** are included in a zone **1**; ports **8** and **12** are included in a zone **2**; and ports **11** and **15** are included in a zone **3**. The zones are similarly set in the description below also.

When the power saving mode of the switch **301** is off, that is, when the power control unit **313** is not operating, all the ports **341** are being powered on irrespective of whether zones are defined or not.

Next, a process performed in the case where the power saving mode is turned on will be described.

FIG. **7** is a diagram illustrating the system when the power saving mode of the switch is turned on.

In FIG. **7**, the servers **201-1** and **202-2** and the storages **401-1** to **401-3** are being powered on, and the server **201-3** is being powered off.

When the power saving mode is turned on, the power saving program **332** starts. That is, by the power saving program **332** being read out into the volatile memory **321** and the CPU **311** executing the power saving program **332** on the volatile memory **321**, the power control unit **313** operates.

The power control unit **313** refers to the zone DB **334** and powers off ports for which a zone is not defined. In FIG. **7**, the ports **1**, **2**, **3**, **5**, **6**, **7**, **9**, **10**, **13** and **14** are powered off.

The power control unit **313** refers to the zone DB **334** and the name server DB **333**. If a server connected to a port for which a zone is defined is not being powered on, the port connected to the server is changed to be in the "power saving mode". In FIG. **7**, the port **11** enters the power saving mode.

If all server-side ports in a zone enter the "power saving mode", the power control unit **313** powers off ports connected to storages which are in the same zone. In FIG. **7**, the port **15** is powered off.

The power control unit **313** records the changed state of the port to the connection state table **335**.

FIGS. **8**A to **8**D are a sequence diagram illustrating a process of the system when the power saving mode is turned on.

In step S**501**, an operations manager turns on the power saving mode of the switch **301**. Thereby, the power saving program **332** is read out into the volatile memory **321**, the CPU **311** executes the power saving program **332** on the volatile memory **321**, and the power control unit **313** starts an operation.

In step S**502**, the power control unit **313** reads out the zone DB **334**. If a zone definition is written in the zone DB **334**, the control proceeds to step S**503**. If a zone definition is not written, the process ends.

In step S**503**, the power control unit **313** selects one unselected port **341** to be targeted by the following process. For example, the power control unit **313** makes the selection in the ascending order of index numbers of the ports **341**.

In step S**504**, the power control unit **313** reads out the zone DB **334**.

In step S**505**, the power control unit **313** refers to zone names and member names in the zone DB **334** and checks whether the selected port **341** is included in a zone. If the selected port **341** is included in a zone, the control proceeds to step S**506**. If the selected port **341** is not included in a zone, the control proceeds to step S**507**.

In step S**506**, the power control unit **313** powers on the selected port **341**.

In step S**507**, the power control unit **313** powers off the selected port **341**.

In step S508, the power control unit 313 reads out the name server DB 333 and acquires information (the device name, connection destination port name, device type, and connection state) about a device connected to the selected port 341.

In step S509, the power control unit 313 checks the device type of the device connected to the selected port 341 on the basis of the acquired device information. If the device type is "Initiator", the control proceeds to step S510. If the device type is not "Initiator", the process ends.

In step S510, the power control unit 313 checks the connection state of the device connected to the selected port 341 on the basis of the acquired device information. If the connection state is "Online", the control proceeds to step S511. If the connection state is "Offline", the process ends.

In step S511, if the device connected to the selected port 341 is a server (that is, the device type is Initiator), and the connection state of the server is Offline, the power control unit 313 causes the selected port 341 to be in the power saving mode. More specifically, the power control unit 313 instructs the switch control unit 312 to stop transmission of an electric signal from the selected port 341, and the switch control unit 312 stops transmission of an electric signal from the selected port 341. Thereby, the selected port 341 performs only reception of an electric signal, and, therefore, power consumption is reduced.

In step S512, the power control unit 313 updates the connection state table 335. More specifically, the power control unit 313 updates the port, the zone name, and the device type in the connection state table 335 to the index number of the selected port 341, the zone name of the zone which includes the selected port 341, the device type of the device connected to the selected port 341, respectively. The power control unit 313 updates the power state in the connection state table 335 to "On" if the selected port 341 is powered on, updates the power state in the connection state table 335 to "Off" if the port 341 is powered off, and updates the power state in the connection state table 335 to "Saving" if the port 341 is caused to be in the power saving mode.

In step S513, the power control unit 313 refers to the connection state table 335 and checks whether the connection states of all servers in the zone which includes the selected port 341 are "Offline". If the connection states of all the servers in the zone which includes the selected port 341 are "Offline", the control proceeds to step S514. If the connection state of any of the servers in the zone which includes the selected port 341 is "Online", the process ends.

In step S514, the power control unit 313 powers off a port 341 to which a storage 401 is connected in the zone which includes the selected port 341. The power control unit 313 changes the power state of the port 341 which has been powered off in the connection state table 335, to "Off".

In step S515, if processing has been performed for all the ports 341 (that is, all the ports have been selected at step S503), the process ends. If there is a port for which processing has not been performed, the control returns to step S503.

Next, a process performed in the case where a server is powered off will be described.

FIG. 9 is a diagram illustrating the system when a server is powered off.

FIG. 9 illustrates the system when the server 201-2 has been powered off in the system state described with reference to FIG. 7.

When the server 201-2 is powered off, the power control unit 313 refers to the zone DB 334 and the name server DB 333 and changes the port 8 connected to the server 201-2 to be in the power saving mode.

If all ports connected to servers in a zone which includes the port 8 are in the power saving mode, the power control unit 313 powers off the port 12 connected to a storage which is in the same zone.

FIGS. 10A to 10D are sequence diagrams illustrating a process of the system when a server is powered off.

In step S601, the operations manager powers off a server 201. When the server 201 is powered off, its connection state in the name server DB 333 is changed to "Offline".

In step S602, the power control unit 313 detects that the connection state in the name server DB 333 has been changed to "Offline". That is, the power control unit 313 detects that the server 201 has been powered off (connection with the server 201 has become offline).

In step S603, the power control unit 313 reads out the zone DB 334. If a zone definition is written in the zone DB 334, the control proceeds to step S604. If a zone definition is not written, the process ends.

In step S604, the power control unit 313 updates the connection state of a port connected to the offline server 201 in the connection state table 335 to "Offline", with the port connected to the offline server 201 as a key.

In step S605, the power control unit 313 searches the connection state table 335, with the port connected to the offline server 201 as a key, to acquire a zone name and a device type corresponding to the port connected to the offline server 201.

In step S606, if the device type acquired at step S605 is Initiator, the control proceeds to step S607. If the device type is not Initiator, the process ends.

In step S607, the power control unit 313 updates the power state of the port connected to the offline server 201 in the connection state table 335 to "Saving". The power control unit 313 causes the port connected to the offline server 201 to be in the power saving mode. More specifically, the power control unit 313 instructs the switch control unit 312 to stop transmission of an electric signal from the port connected to the offline server 201, and the switch control unit 312 stops transmission of an electric signal from the port connected to the offline server 201.

In step S608, the power control unit 313 searches the connection state table 335, with the zone name acquired in step S605, the device type "Initiator" and the connection state "Online" as search conditions. The power control unit 313 counts the number of records detected by the search.

In step S609, if the value of the number counted at step S608 is larger than 0, the process ends. If the value of the number counted at step S608 is 0, the control proceeds to step S610.

In step S610, the power control unit 313 searches the connection state table 335, with the zone name acquired at step S605, the device type "Target" and the connection state "Online" as search conditions. The power control unit 313 powers off the port 341 of a record found by the search. The power control unit 313 updates the connection state and power state of the record found by the search of the connection state table 335 to "Offline" and "Off", respectively.

Next, a process performed in the case where a server is powered on will be described.

FIG. 11 is a diagram illustrating the system when a server is powered on.

FIG. 11 is a diagram illustrating the system when the server 201-2 is powered on in the system described with reference to FIG. 9.

When the server **201-2** is powered on, a signal from the server **201-2** is received by the port **8** which is in the power saving mode.

The power control unit **313** analyzes the content of the received signal and, if the received signal is a signal destined for a storage, stores the received signal. The power control unit **313** powers on the port **8** which has received the signal (that is, the port **8** connected to the server **201-2**). The power control unit **313** refers to the zone DB **334**, powers on the port **12** connected to a storage which is in the same zone as the port which has received the signal, establishes communication with the storage **401-2**, and then transmits the stored signal from the server **201-2** to the storage **401-2**.

FIGS. **12**A to **12**F are diagrams illustrating a process of the system when a server is powered on.

In the description below, a port connected to a server **201**, and a port connected to a storage **401** may be expressed as a server-side port and a storage-side port, respectively.

In step S**701**, the operations manager powers on a server **201**. When the server **201** is powered on, a connection state corresponding to a port connected to the server **201** in the name server DB **333** is changed to "Online".

In step S**702**, the server **201** transmits a signal for establishing connection between the server **201** and the storage **401**, to the storage **401**.

In step S**703**, the switch **301** receives the signal for establishing connection between the server **201** and the storage **401** at the server-side port.

In step S**704**, the power control unit **313** checks the destination of the received signal. If the destination of the signal is the switch, the control proceeds to step S**705**. If the destination of the signal is the storage, the control proceeds to step S**707**.

In step S**705**, the power control unit **313** does not do anything.

In step S**706**, the switch control unit **312** powers on the port which has received the signal and replies to the server **201** to the effect that the signal has been received.

In step S**707**, the power control unit **313** reads out the zone DB **334**. If a zone definition is written in the zone DB **334**, the control proceeds to step S**708**. If a zone definition is not written, the process ends.

In step S**708**, the power control unit **313** stores the signal received from the server **201** into the volatile memory **321** or the nonvolatile memory **331**. The power control unit **313** updates the connection state of the port which has received the signal in the connection state table **335** to "Online", with the port which has received the signal (that is, the port to which the powered-on server **201** is connected) as a key.

In step S**709**, the power control unit **313** searches the connection state table **335**, with the port which has received the signal as a key, to acquire a zone name and a device type corresponding to the port which has received the signal.

In step S**710**, if the device type acquired at step S**709** is "Target", the process ends. If the device type acquired at step S**709** is "Initiator", the control proceeds to step S**711**.

In step S**711**, the power control unit **313** updates the power state of the port which has received the signal in the connection state table **335** to "On", with the port which has received the signal as a key. The power control unit **313** powers on the port which has received the signal.

In step S**712**, the power control unit **313** searches the connection state table **335**, with the zone name acquired at step S**709**, the device type "Target" and the connection state "Online" as search conditions. The power control unit **313** powers on the port **341** of a record found by the search. The power control unit **313** updates the connection state and power state of the record found by the search of the connection state table **335** to "Online" and "On", respectively.

In step S**713**, the power control unit **313** transmits the signal to establish connection between the switch **301** and the storage **401**, to the storage **401**.

In step S**714**, the storage **401** receives the signal from the switch **301** and returns a signal for establishing connection between the storage **401** and the switch **301**, to the switch **301**.

In step S**715**, the switch **301** receives the signal for establishing connection between the storage **401** and the switch **301**, from the storage **401**. The switch control unit **312** updates the connection state of a port connected to the storage in the name server DB **333** to "Online".

In step S**716**, by referring to the name server DB **333** and finding that the connection state of the port connected to the storage is "Online", the power control unit **313** confirms that connection with the storage **401** has been established. The power control unit **313** transmits the stored signal for establishing connection between the server **201** and the storage **401**, to the storage **401**.

In step S**717**, the storage **401** receives the signal for establishing connection between the server **201** and the storage **401** which has been transmitted from the server **201**, from the switch **301**, and transmits a signal for establishing connection between the storage **401** and the server **201**, which is destined for the server, to the switch **301**.

In step S**718**, the switch **301** receives the signal from the storage **401** and relays the signal to the server **201**.

In step S**719**, the server **201** receives and transmits the signal for establishing connection with the switch **301**.

According to the switch of the embodiment, it is possible to reduce power consumption. Furthermore, according to the switch of the embodiment, it is possible to execute power control of a port depending on the state of a device connected to the port.

All examples and conditional language provided herein are intended for pedagogical purposes to aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed as being limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A switch connected to external devices, the switch comprising:

a plurality of ports connected to the external devices;

a storage unit to store a zone database indicating a group in which each of the plurality of ports is included; and

a processor to perform power control of the plurality of ports and permit communication only between ports included in the same group, on the basis of the zone database,

the processor powers off a port that is not included in any groups among the plurality of ports, on the basis of the zone database,

the external devices are an information processing device or a storage device storing data;

the storage unit further stores a name server database in which a type of the external device connected to each

of the plurality of ports and a state of connection with the external device are written; and

the processor continuously transmits a signal from a port when the port is being powered on, refers to the name server database, determines whether the state of connection with the external device is offline and the type of the external device is the information processing device based on the name server database, and, when the state of connection with the external device is offline and the type of the external device is the information processing device, stops transmission of the signal from the port connected to the information processing device.

2. The switch according to claim **1**, wherein

the storage unit further stores a connection state table in which the group in which each of the plurality of ports is included, the type of the external device connected to each of the plurality of ports, and the state of connection with the external device are written; and

when states of connection with all information processing devices connected to ports included in the same group that includes the port to which the information processing device whose state of connection is offline is connected are offline, on the basis of the connection state table, the processor powers off a port connected to the storage device, among the ports included in the same group.

3. A switch connected to external devices, the switch comprising:

a plurality of ports connected to the external devices;

a storage unit to store a zone database indicating a group in which each of the plurality of ports is included, and a connection state information in which the group in which each of the plurality of ports is included, a type of the external device connected to each of the plurality of ports, and a state of connection with the external device are written; and

a processor to perform power control of the plurality of ports, permit communication only between ports included in the same group, on the basis of the zone database, and continuously transmit a signal from a port when the port is being powered on, wherein

the processor detects that the external device has been powered off, refers to the connection state information, determines whether the type of the external device that has been powered off is an information processing device based on the connection state information, and, when the type of the external device that has been powered off is the information processing device, stops transmission of the signal from a port connected to the information processing device that has been powered off.

4. The switch according to claim **3**, wherein the processor refers to the connection state information, and, when there is not a port connected to an information processing device that is being powered on, among ports in a group that includes the port connected to the information processing device that has been powered off, powers off ports connected to storage devices, among the ports in the group that includes the port connected to the information processing device that has been powered off.

5. A control method executed by a switch comprising a plurality of ports connected to external devices and a storage unit storing a zone database indicating a group in which each of the plurality of ports is included, and permitting communication only between ports included in the same group, the method comprising:

referring to the zone database; and

powering off a port that is not included in any groups among the plurality of ports,

the external devices are an information processing device or a storage device storing data;

the storage unit further stores a name server database in which a type of the external device connected to each of the plurality of ports and a state of connection with the external device are written; and

the switch continuously transmits a signal from a port when the port is being powered on; and

the control method further comprises:

referring to the name server database;

determining whether the state of connection with the external device is offline and the type of the external device is the information processing device based on the name server database; and

when the state of connection with the external device is offline and the type of the external device is the information processing device, stopping transmission of the signal from the port connected to the information processing device.

6. The control method according to claim **5**, wherein

the storage unit further stores a connection state information in which the group in which each of the plurality of ports is included, the type of the external device connected to each of the plurality of ports, and the state of connection with the external device are written; and

the control method further comprises:

referring to the connection state information; and

when states of connection with all information processing devices connected to ports included in the same group that includes the port to which the information processing device whose state of connection is offline is connected are offline, powering off a port connected to the storage device, among the ports included in the same group.

7. A control method executed by a switch comprising a plurality of ports connected to external devices and a storage unit storing a zone database indicating a group in which each of the plurality of ports is included, and a connection state information in which the group in which each of the plurality of ports is included, a type of the external device connected to each of the plurality of ports, and a state of connection with the external device are written, permitting communication only between ports included in the same group, on the basis of the zone database, and continuously transmitting a signal from a port when the port is being powered on, the method comprising:

detecting the external device has been powered off;

referring to the connection state information;

determining whether the type of the external device that has been powered off is an information processing device based on the connection state information; and

when the type of the external device that has been powered off is the information processing device, stopping transmission of the signal from the port connected to the information processing device that has been powered off.

8. The control method according to claim **7**, further comprising:

referring to the connection state information; and

when there is not a port connected to an information processing device that is being powered on, among ports in a group that includes the port connected to the information processing device that has been powered off, powering off ports connected to storage devices,

among the ports in the group that includes the port connected to the information processing device that has been powered off.

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