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(54) DATA BACKUP SYSTEM AND METHOD WITH DATA CONSISTENCY USING ASYNCHRONOUS DATA COPY

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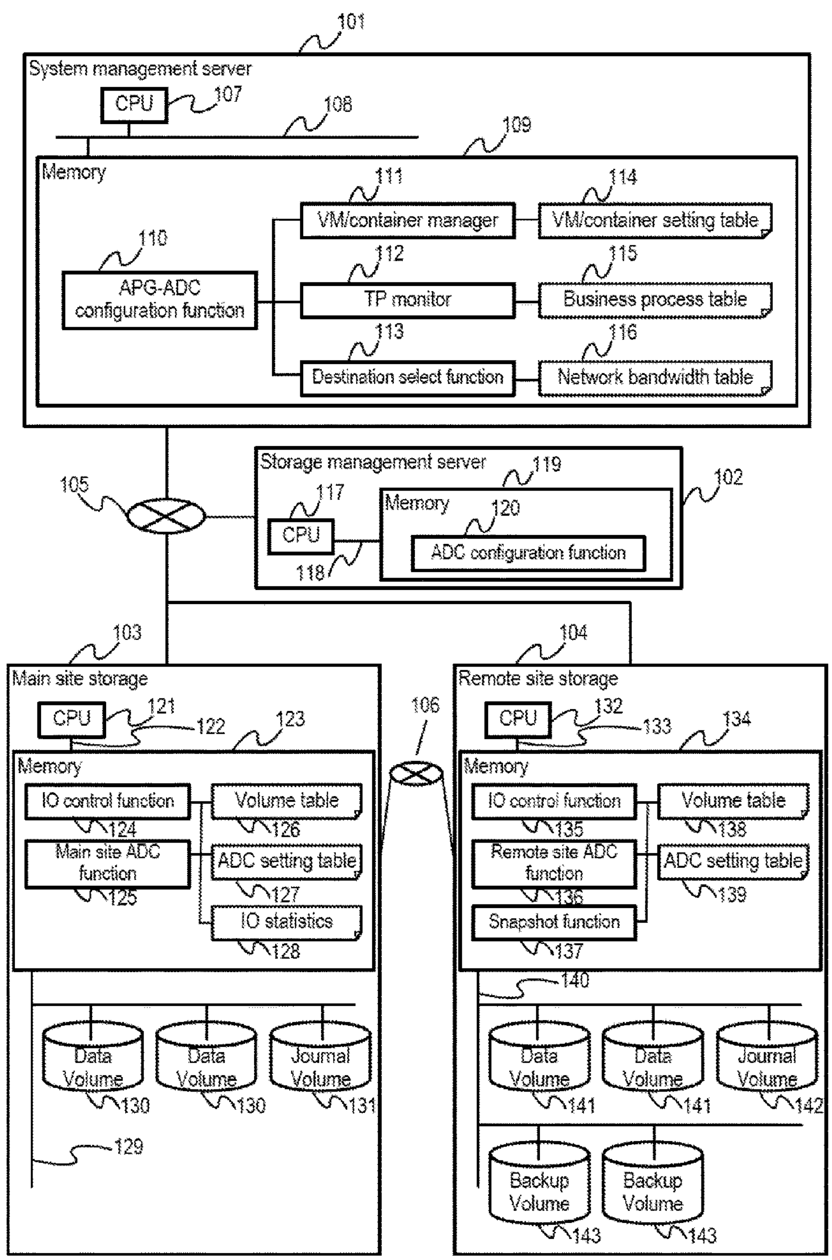
(57) ABSTRACT

Backup systems and methods create consistent backups across multiple data sets, while integrating ADC technology. To accomplish this, an application group ADC configuring function (APG-ADC configuring function) configures the ADC to ensure that backup data sets remain consistent with those at the original source. The APG-ADC configuring function configures ADC such as to update backup data sets in the same order as the original data sets.



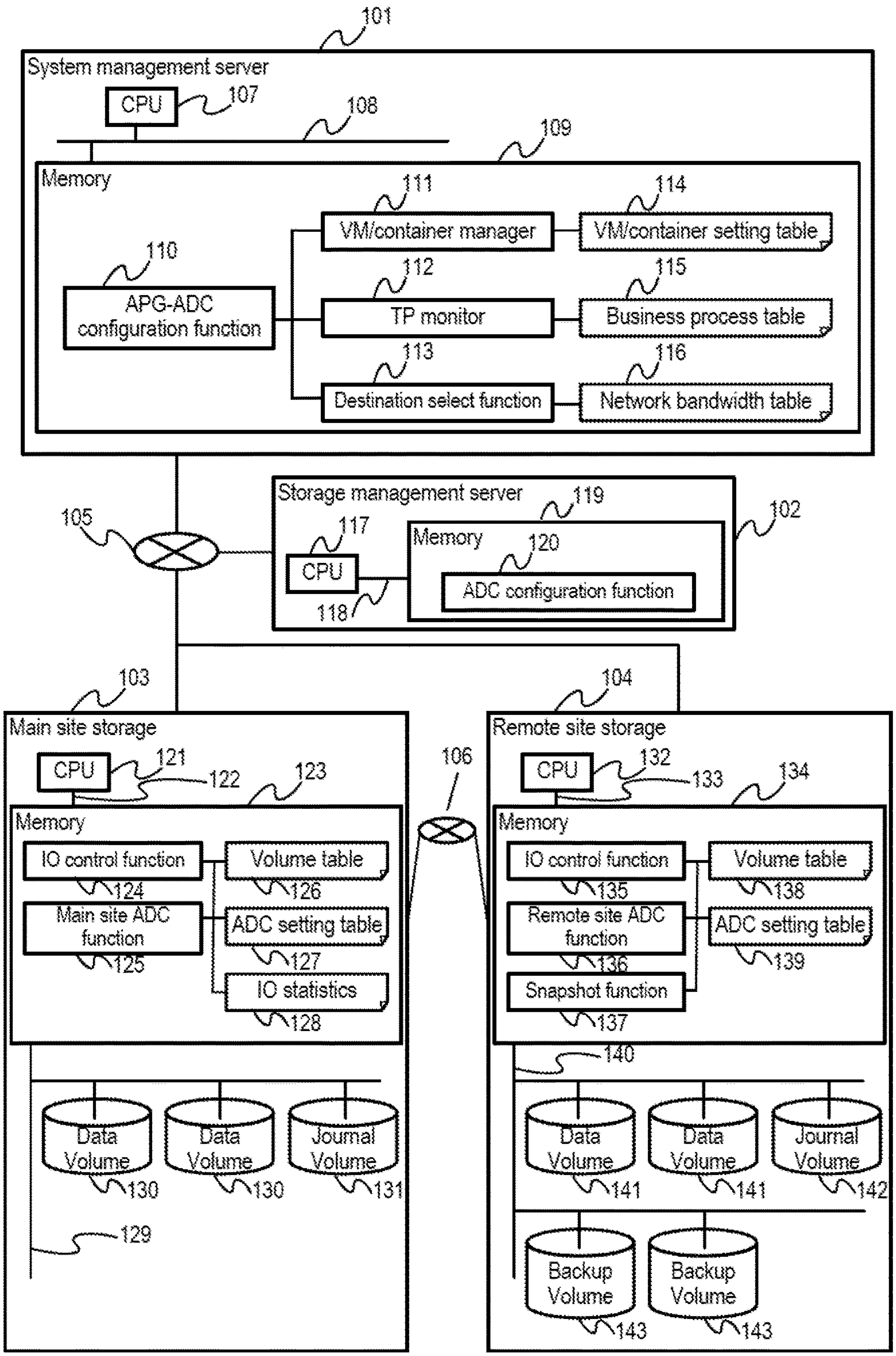

101
System management server
CPU
107
108
109
Memory
110
APG-ADC configuration function
111
VM/container manager
112
TP monitor
113
Destination select function
114
VM/container setting table
115
Business process table
116
Network bandwidth table
105
Storage management server
119
102
117
CPU
118
Memory
120
ADC configuration function
103
Main site storage
CPU
121
122
123
Memory
IO control function
124
Volume table
126
Main site ADC function
125
ADC setting table
127
IO statistics
128
Data Volume
130
Data Volume
130
Journal Volume
131
129
106
104
Remote site storage
CPU
132
133
134
Memory
IO control function
135
Volume table
138
Remote site ADC function
136
ADC setting table
139
Snapshot function
137
140
Data Volume
141
Data Volume
141
Journal Volume
142
Backup Volume
143
Backup Volume
143

FIG. 1

201 202 203 204 205

VM/pod ID	VM/pod name	Related volumes	Label	Label value
1	DB1	Volume1, Volume3	Consistent group	CTG1
2	DB2	Volume2	Consistent group	CTG1, end
⋮	⋮	⋮	⋮	⋮

FIG. 2

301 302 303

Business process ID	Business process name	VM/Pod IDs
1	Sales	1, 2
2	Payment	1.3
⋮	⋮	⋮

FIG. 3

401 402 403

Original site	Business process name	VM/Pod IDs
Main site	Remote site 1	100 Mbps
Main site	Remote site 2	200 Mbps
⋮	⋮	⋮

FIG. 4

501 502 503

Volume	Device	Address range
Volume 1	Flash device 1	0-1000
Volume2	Flash device 2	0-2000
⋮	⋮	⋮

FIG. 5

601 602 603 604

Origin Volume group	Origin journal volume	Destination journal volume	Destination volume group
Volumn1, Volumn2	JnlVolumn1	JnlVolumn101	Volume101, Volume102
Volumn3	JnlVolumn2	JnlVolumn102	Volume103
⋮	⋮	⋮	⋮

FIG. 6

701 702

Volume	IO statistics
Volume1	100GB/hour
Volume2	200GB/hour
⋮	⋮

FIG. 7

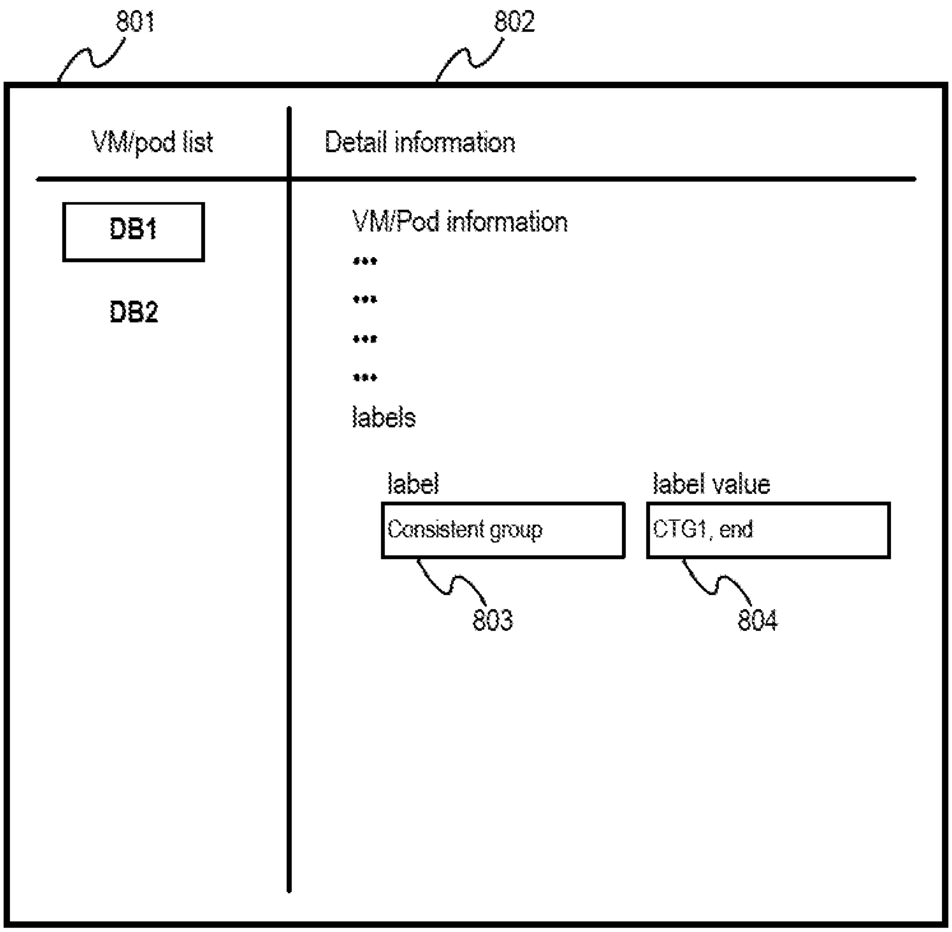

801
802
VM/pod list
Detail information
DB1
DB2
VM/Pod information
•••
•••
•••
•••
labels
label
label value
Consistent group
CTG1, end
803
804

FIG. 8

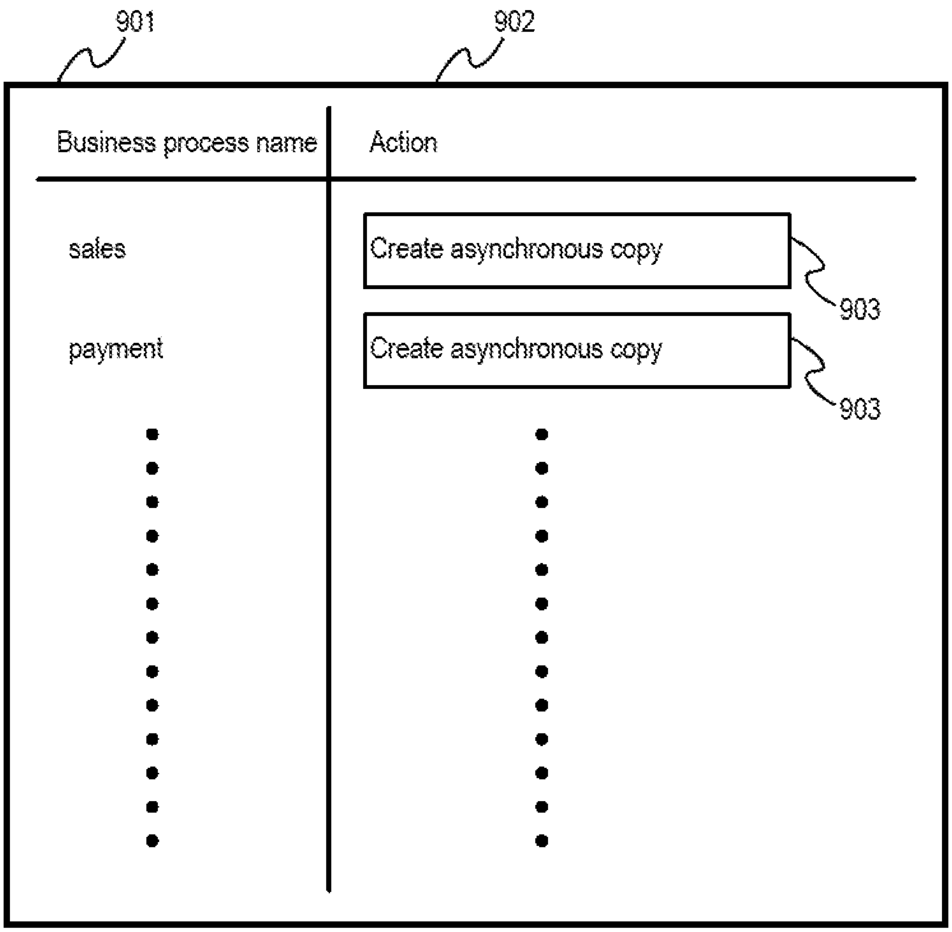

901
902
Business process name
Action
sales
Create asynchronous copy
903
payment
Create asynchronous copy
903

FIG. 9

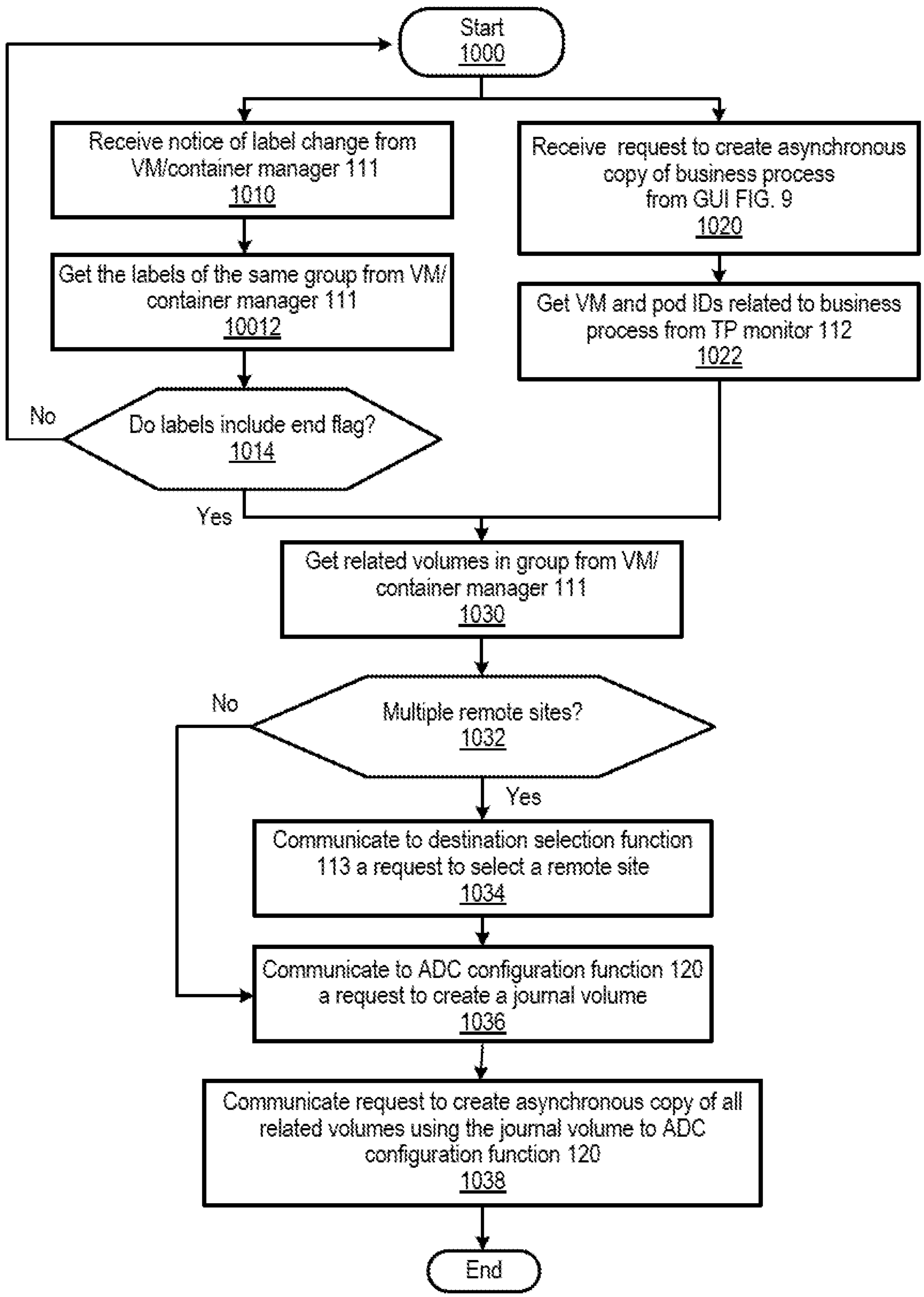

Start
1000
Receive notice of label change from VM/container manager 111
1010
Get the labels of the same group from VM/ container manager 111
10012
Do labels include end flag?
1014
No
Yes
Receive request to create asynchronous copy of business process from GUI FIG. 9
1020
Get VM and pod IDs related to business process from TP monitor 112
1022
Get related volumes in group from VM/ container manager 111
1030
Multiple remote sites?
1032
No
Yes
Communicate to destination selection function 113 a request to select a remote site
1034
Communicate to ADC configuration function 120 a request to create a journal volume
1036
Communicate request to create asynchronous copy of all related volumes using the journal volume to ADC configuration function 120
1038
End

FIG.10

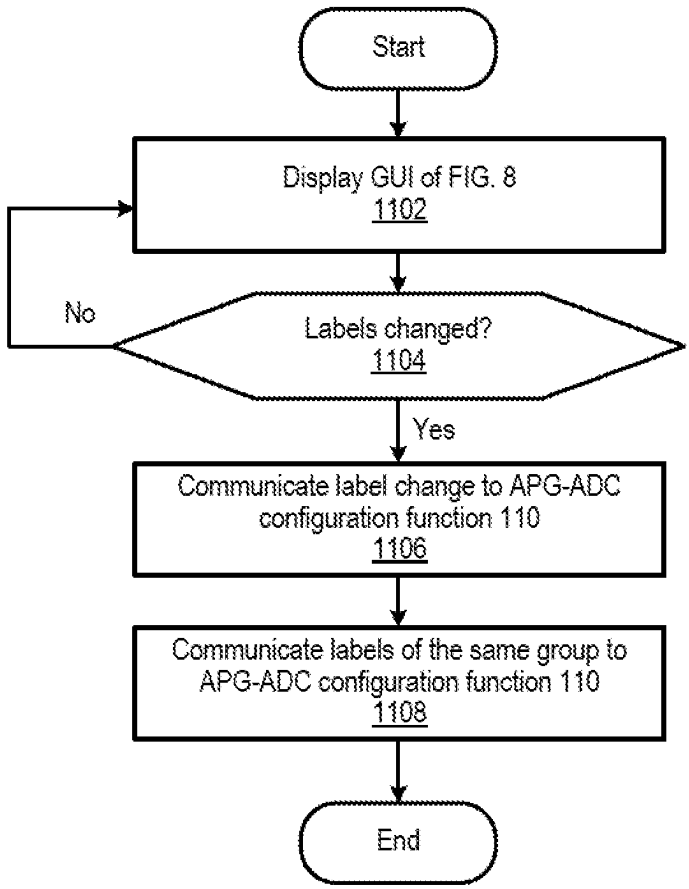

Start
Display GUI of FIG. 8
1102
No
Labels changed?
1104
Yes
Communicate label change to APG-ADC configuration function 110
1106
Communicate labels of the same group to APG-ADC configuration function 110
1108
End

FIG. 11

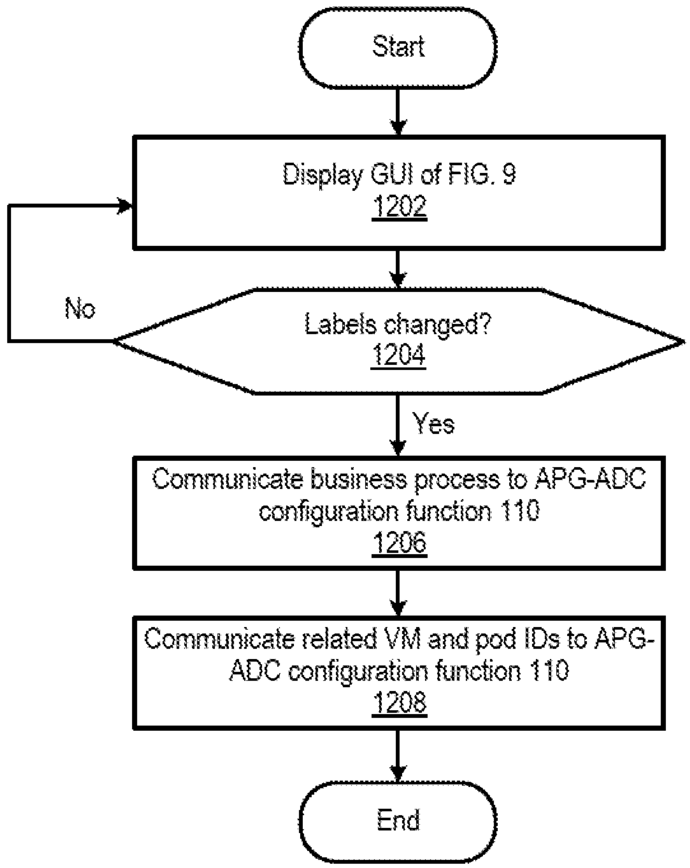

Start
Display GUI of FIG. 9
1202
No
Labels changed?
1204
Yes
Communicate business process to APG-ADC configuration function 110
1206
Communicate related VM and pod IDs to APG-ADC configuration function 110
1208
End

FIG. 12

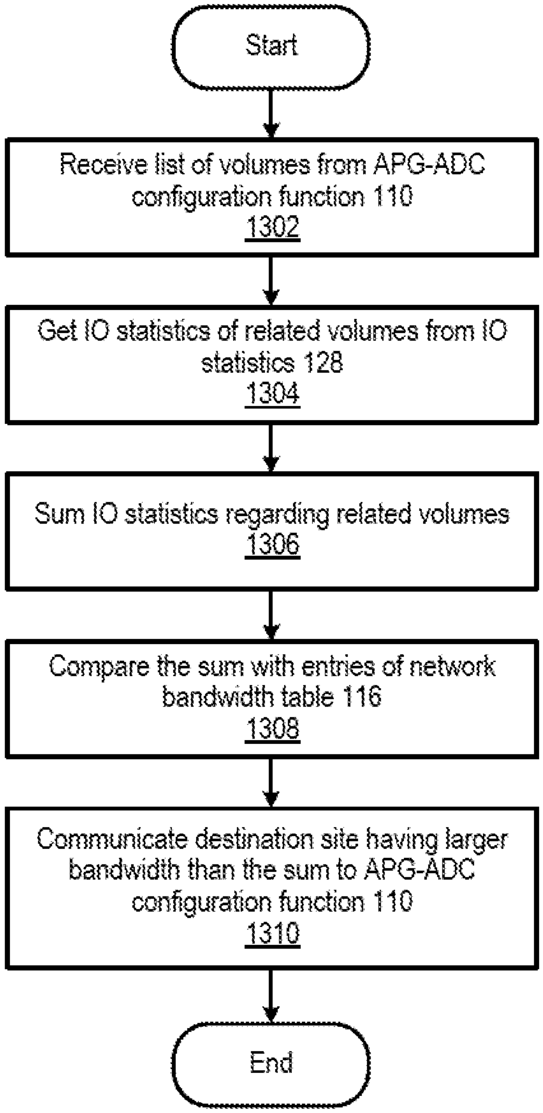

Start
Receive list of volumes from APG-ADC configuration function 110
1302
Get IO statistics of related volumes from IO statistics 128
1304
Sum IO statistics regarding related volumes
1306
Compare the sum with entries of network bandwidth table 116
1308
Communicate destination site having larger bandwidth than the sum to APG-ADC configuration function 110
1310
End

FIG. 13

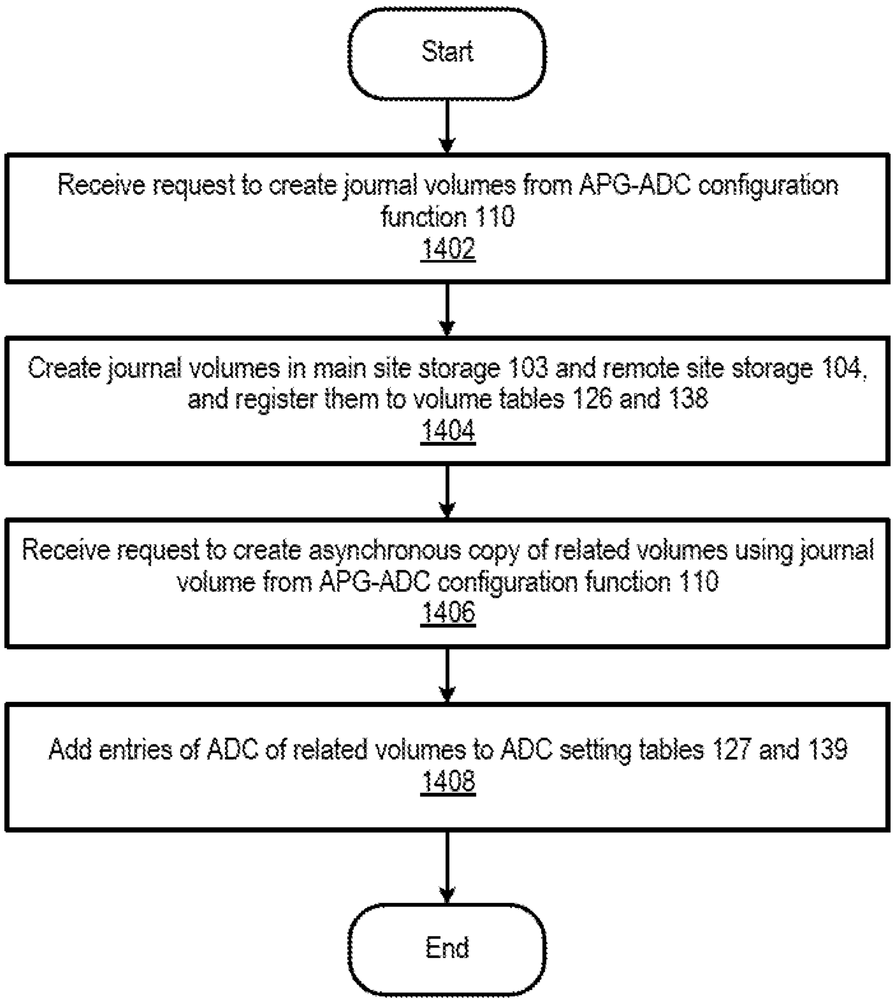

Start
Receive request to create journal volumes from APG-ADC configuration function 110
1402
Create journal volumes in main site storage 103 and remote site storage 104, and register them to volume tables 126 and 138
1404
Receive request to create asynchronous copy of related volumes using journal volume from APG-ADC configuration function 110
1406
Add entries of ADC of related volumes to ADC setting tables 127 and 139
1408
End

FIG. 14

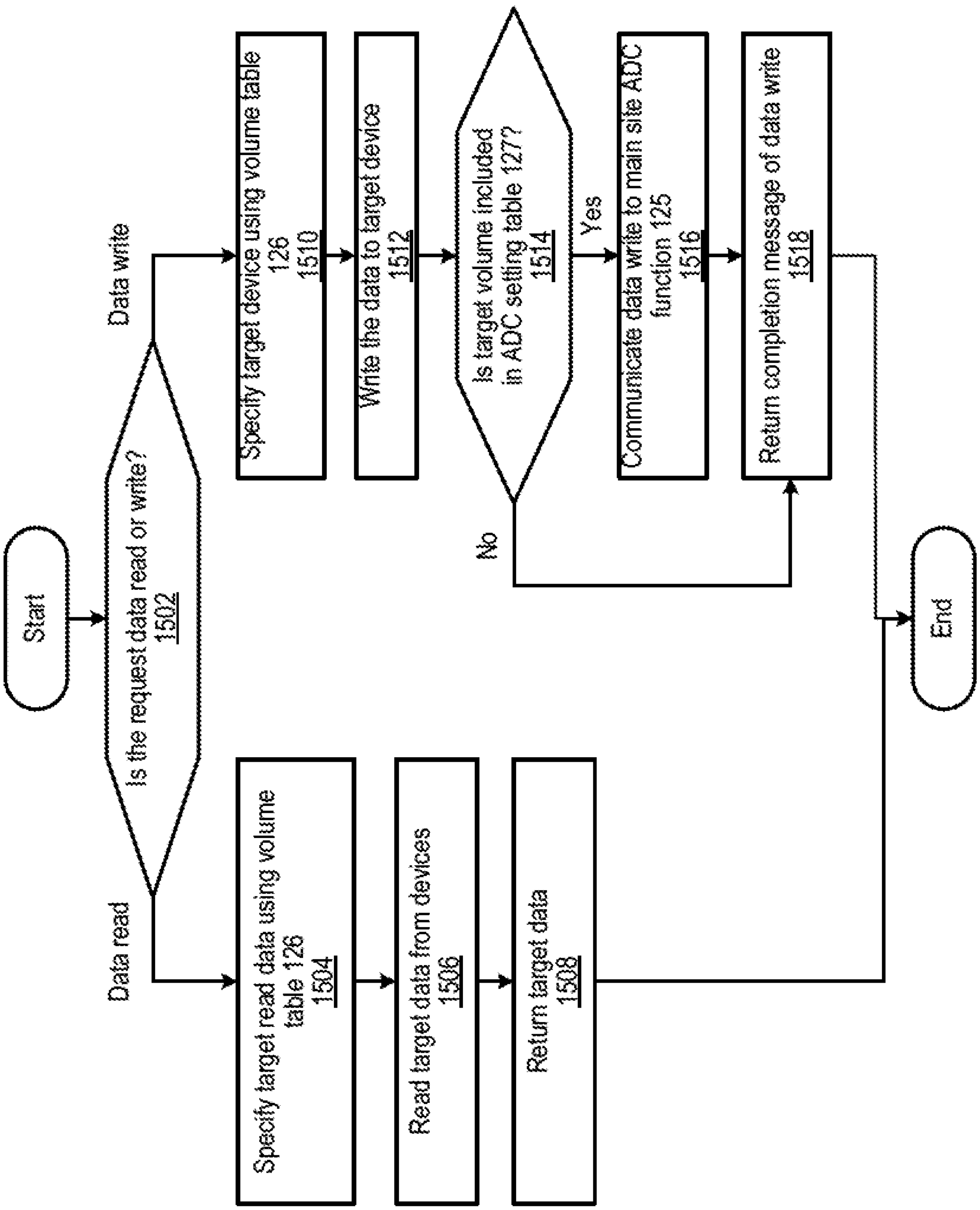

Start
Is the request data read or write?
1502
Data read
Data write
Specify target read data using volume table 126
1504
Read target data from devices
1506
Return target data
1508
Specify target device using volume table 126
1510
Write the data to target device
1512
Is target volume included in ADC setting table 127?
1514
Yes
No
Communicate data write to main site ADC function 125
1516
Return completion message of data write
1518
End

FIG. 15

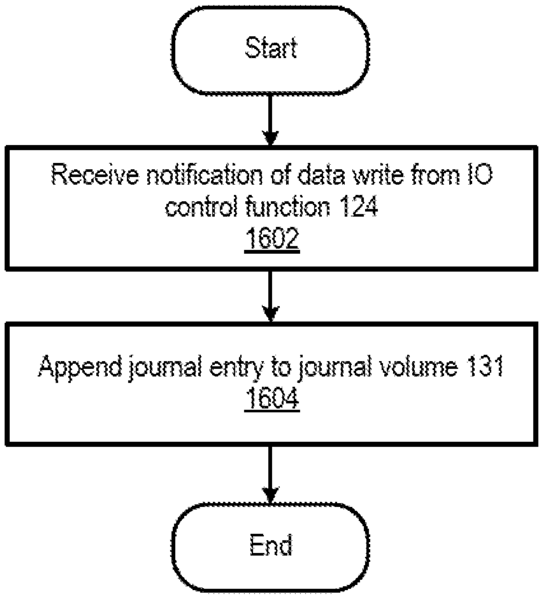


FIG. 16

Sequence No	Volume name	Volume address	Write data
1	Volume1	1000	xxxxxxxxxxxxxxx
2	Volume2	2000	yyyyyyyyyyyyyyy
3	Volume1	1500	xyzxyzxyzxyzxyz
⋮	⋮	⋮	⋮

FIG. 17

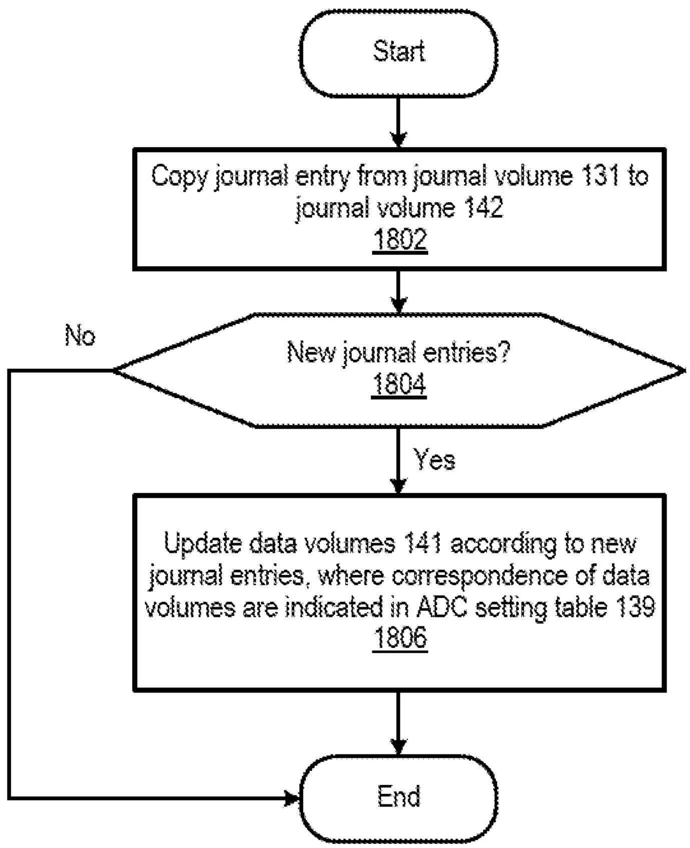

Start
Copy journal entry from journal volume 131 to journal volume 142
1802
New journal entries?
1804
No
Yes
Update data volumes 141 according to new journal entries, where correspondence of data volumes are indicated in ADC setting table 139
1806
End

FIG. 18

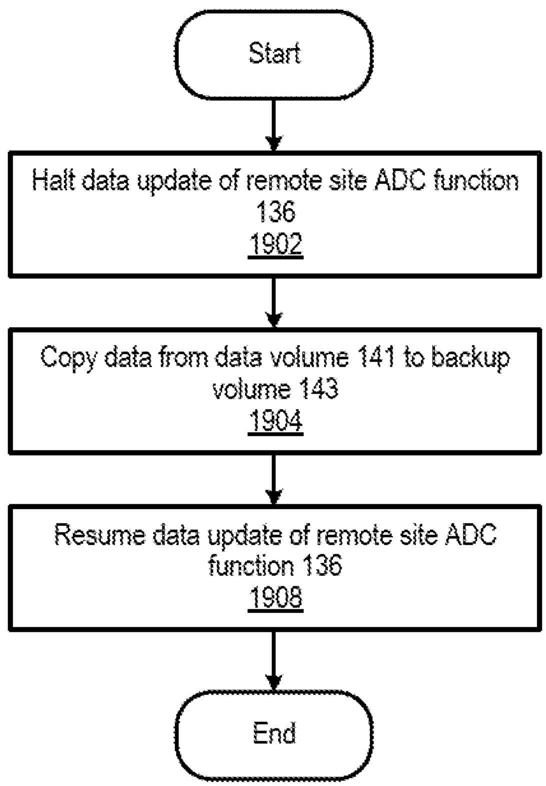

Start
Halt data update of remote site ADC function 136
1902
Copy data from data volume 141 to backup volume 143
1904
Resume data update of remote site ADC function 136
1908
End

FIG. 19

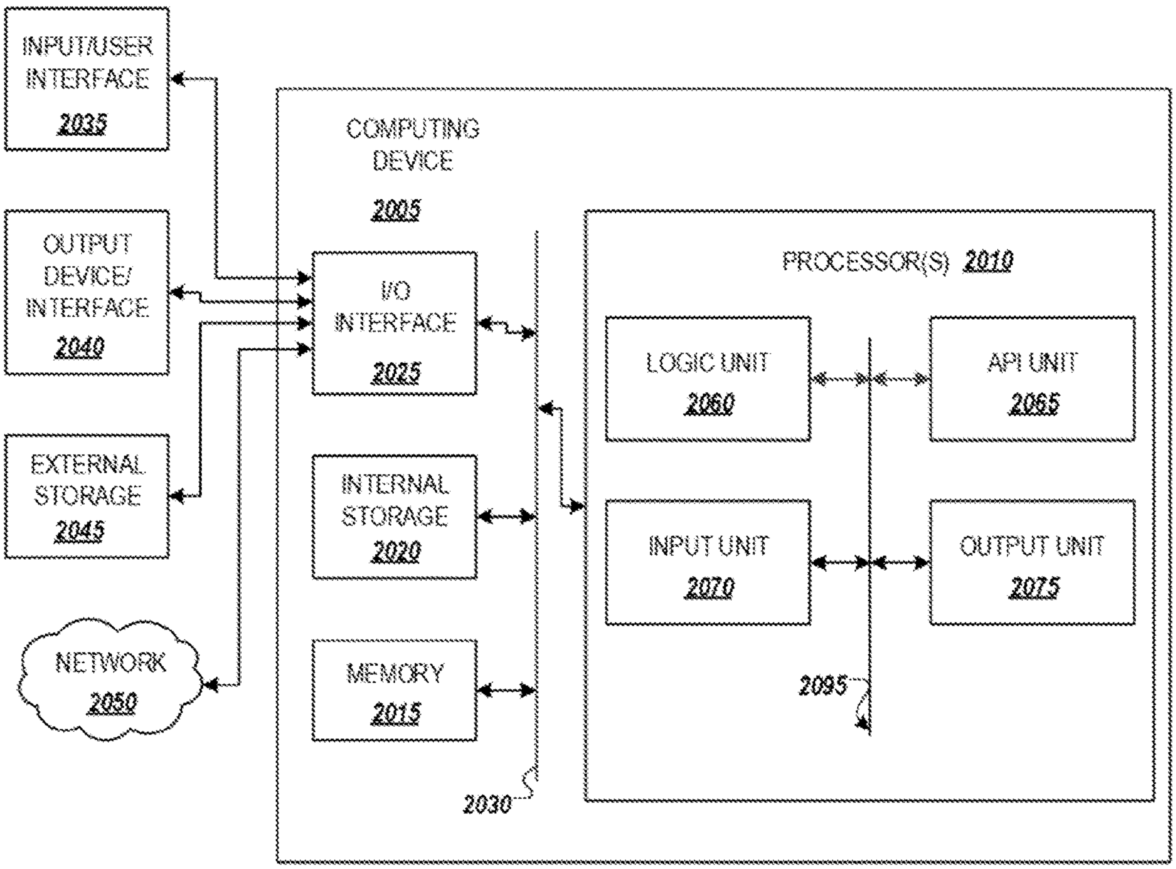

INPUT/USER INTERFACE 2035
OUTPUT DEVICE/ INTERFACE 2040
EXTERNAL STORAGE 2045
NETWORK 2050
COMPUTING DEVICE 2005
I/O INTERFACE 2025
INTERNAL STORAGE 2020
MEMORY 2015
2030
PROCESSOR(S) 2010
LOGIC UNIT 2060
API UNIT 2065
INPUT UNIT 2070
OUTPUT UNIT 2075
2095

FIG. 20

DATA BACKUP SYSTEM AND METHOD WITH DATA CONSISTENCY USING ASYNCHRONOUS DATA COPY

BACKGROUND

Field

[0001] The present disclosure is directed to backup storage systems, and more specifically, toward systems and methods for creating consistent backups across multiple data sets, while integrating asynchronous data copy (ADC) technology.

Related Art

[0002] Data backup is a core technology for enhancing resilience against system failures. Such failures may be caused by a variety of incidents, including hardware malfunction, software bugs, operational errors, cyber-attacks, and natural disasters. These incidents can inflict severe damage on a system. Data backup protects a system's most important asset, the data itself, which ideally can be fully recovered. However, traditional data backup methods oftentimes lead to issues like diminished online performance and the need for business operations to be suspended. To address the former issue, ADC methods can be employed to mitigate the impact. ADC performs data copying asynchronously with a data write to the original source. That is, the backup data are updated independently of the data write. In this manner, ADC can remove the impact of online performance on business processes. When a system requires storing backup data at remote sites, such as in geometrically distributed cloud systems, where long delays caused by physical distance are inevitable absent the use of ADC. Thus, ADC has become the prevailing method for removing the first factor, especially in cloud-based systems.

[0003] Regarding the second challenge, system administrators oftentimes have to halt business operations to perform data backups. For example, banking systems refuse to accept new transactions during scheduled backup times, e.g., at midnight. In database systems, suspending business operations is a requirement for creating consistent backups, meaning that database shutdowns are required for achieving backup consistency.

[0004] Furthermore, enterprise systems can include multiple distributed databases that can be managed by a transaction processing monitor (TP monitor). The TP monitor coordinates business processes across multiple resources, such as inventory and payment databases in e-commerce systems. Creating consistent backups across multiple databases is a challenging task for system administrators. Therefore, halting business activities remains a common approach despite its negative effects on business operations.

[0005] ADC is the prevailing technology for avoiding degradation of online performance, which can be implemented in a storage system. Some approaches employ a journal volume to record actions and data updates made to the original data. The records stored in the journal volume are copied to the backup site such that the backup data can be updated according to these records.

[0006] To achieve consistent backup across multiple data sets, "consistent groups" are established among virtual machines. A consistent group is used for specifying multiple data sets that require data consistency or synchronization to maintain data integrity. In some approaches, multiple data sets are locked prior to backup to ensure consistency among the data sets. However, such approaches are based on the virtual machine layer and necessitate halting data processing.

[0007] Currently, the TP monitor method is widely adopted for managing multiple resources. In some approaches, a system with a TP monitor implements transaction processing across multiple data sets. However, such approaches have difficulties in developing consistency among multiple backups or data sets when using ADC. For example, even if data is copied using ADC, it does not guarantee consistent backups across the different data sets. Conversely, approaches capable of producing consistent backups are not integrated with ADC technology. Other approaches that require locking resources before backup lead to interruptions in business operations. Therefore, it is desirable to have systems and methods that integrate ADC with consistency mechanisms, allowing for both efficient ADC and the maintenance of backup consistency across multiple data sets without necessitating a suspension of business operations.

SUMMARY

[0008] In some aspects of the disclosure, backup systems and methods create consistent backups across multiple data sets, while integrating ADC technology. To accomplish this, an application group ADC configuring function (APG-ADC configuring function) configures the ADC to ensure that backup data sets remain consistent with those at the original source. Further, the APG-ADC configuring function configures ADC such as to update backup data sets in the same order as the original data sets.

[0009] The APG-ADC configuring function receives information about a group of virtual machines and containers. It then identifies the data volumes related to the group and configures the ADC such as to ensure consistency between backup data sets and original data volumes. The process involves, the APG-ADC configuring function extracting the information of the application group from the TP monitor; identifying the data volumes related to the application group; and configuring the ADC to create consistent backup data sets in some APG.

[0010] Further, a snapshot function produces backup data sets from the asynchronously copied data sets. Because the APG-ADC configuring function ensures that the update sequence of the backup data sets has the same order as that of the original data sets, the snapshot function can produce the desired consistent backup data sets at the remote site. This ensures that the backups not only reflect the latest data but also maintain data integrity necessary for effective data recovery and management.

[0011] Aspects of the present disclosure can involve a system, which can involve means for performing steps comprising: obtaining application group information; obtaining related volumes in a group; and communicating, to an ADC configuration function, a request to create, at a primary site storage, a journal volume that corresponds to a journal volume in a remote site storage; and in response to the primary site storage communicating the journal volume to the remote site storage, creating, based on a set of journal entries in the journal volume, a consistent backup in a backup volume in the remote site storage.

[0012] Aspects of the present disclosure can involve a system for copying data from a primary site including one or more server devices and one or more storage devices to a secondary site including one or more storage devices using asynchronous copying, the system including a processor at the one or more server devices, configured to execute an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

[0013] Aspects of the present disclosure can involve a method for copying data from a primary site including one or more server devices and one or more storage devices to a secondary site including one or more storage devices using asynchronous copying, the method including executing an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

[0014] Aspects of the present disclosure can involve a system for copying data from a primary site including one or more server devices and one or more storage devices to a secondary site including one or more storage devices using asynchronous copying, the system including means for executing an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

[0015] Aspects of the present disclosure can involve a non-transitory computer readable medium, storing instructions for copying data from a primary site including one or more server devices and one or more storage devices to a secondary site including one or more storage devices using asynchronous copying, the method including executing an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

BRIEF DESCRIPTION OF DRAWINGS

[0016] FIG. **1** depicts a block diagram of an exemplary system architecture, in accordance with an example implementation.

[0017] FIG. **2** depicts an example of the VM/container setting table shown in FIG. **1**.

[0018] FIG. **3** depicts an example of the business process table shown in FIG. **1**.

[0019] FIG. **4** depicts an example of the network bandwidth table shown in FIG. **1**.

[0020] FIG. **5** depicts an example of volume tables in the main and remote site storage shown in FIG. **1**.

[0021] FIG. **6** depicts an example of ADC setting tables in the main and remote site storage shown in FIG. **1**.

[0022] FIG. **7** depicts an example of the IO statistics table in the main site storage shown in FIG. **1**.

[0023] FIG. **8** illustrates an example of a graphical user interface (GUI) of the VM/container manager shown in FIG. **1**.

[0024] FIG. **9** depicts an example of a GUI of the APG-ADC configuration function shown in FIG. **1**.

[0025] FIG. **10** is a flowchart illustrating an example process for the APG-ADC configuration function shown in FIG. **1**.

[0026] FIG. **11** is a flowchart illustrating an example process for the VM/container manager shown in FIG. **1**.

[0027] FIG. **12** is a flowchart illustrating an example process for the TP monitor shown in FIG. **1**.

[0028] FIG. **13** is a flowchart illustrating an example process for the destination selection function shown in FIG. **1**.

[0029] FIG. **14** is a flowchart illustrating an example process for the ADC configuration function shown in FIG. **1**.

[0030] FIG. **15** is a flowchart illustrating an example process for the IO control function **124**.

[0031] FIG. **16** is a flowchart illustrating an example process for the main site ADC function shown in FIG. **1**.

[0032] FIG. **17** illustrates an example of journal entries stored in a journal volume.

[0033] FIG. **18** is a flowchart illustrating an example process for the remote site ADC function shown in FIG. **1**.

[0034] FIG. **19** is a flowchart illustrating an example process for the snapshot function shown in FIG. **1**.

[0035] FIG. **20** illustrates an example computing environment with an example computer device suitable for use in some example implementations.

DETAILED DESCRIPTION

[0036] The following detailed description provides details of the figures and example implementations of the present application. Reference numerals and descriptions of redundant elements between figures are omitted for clarity. Terms used throughout the description are provided as examples and are not intended to be limiting. For example, the use of the term "automatic" may involve fully automatic or semi-automatic implementations involving user or administrator control over certain aspects of the implementation, depending on the desired implementation of one of ordinary skill in the art practicing implementations of the present application. Selection can be conducted by a user through a user interface or other input means, or can be implemented through a desired algorithm. Example implementations as described herein can be utilized either singularly or in combination and the functionality of the example implementations can be implemented through any means according to the desired implementations.

[0037] In this document, the terms "primary" and "main," are used interchangeably. Similarly, the terms "service provider," are used interchangeably. The term "consumer" refers to an entity such as an end user. "GUI" and "UI" refer to a graphical user interface.

[0038] FIG. **1** depicts a block diagram of an exemplary system architecture, in accordance with an example implementation. As depicted, system **100** comprises system management server **101**, storage management server **102**, main site storage **103**, remote site storage **104**, system network **105**, and storage network **106**. System network **105** connects system management server **101**, storage management server **102**, main site storage **103**, remote site storage **104**. Similarly, storage network **106** connects main site storage **103** and remote site storage **104**. As depicted, system management server **101** comprises CPU **107**, inner network **108**, and memory **109** that comprises APG-ADC configuration function **110**. APG-ADC configuration function **110**, in turn, comprises VM/container manager **111**, TP monitor **112**, and destination selection function **113** that manages respective VM/container setting table **114**, resource group table **115**, and network bandwidth table **116**.

[0039] Storage management server **102** comprises CPU **117**, inner network **118**, and memory **119**, which comprises ADC configuration function **120**. In operation, ADC configuration function **120** sets the ADC. Similarly, main site storage **103** comprises CPU **121** inner network **122**, and memory **123**. As depicted memory **123** comprises IO control function **124**, main site ADC function **125**, volume table **126**, ADC setting table **127**, and IO statistics **128**. Main site storage **103** further comprises inner storage network **129**, data volume **130**, and journal volume **131**. Remote site storage **104** comprises CPU **132**, inner network **133**, and memory **134**. Memory **134** comprises IO control function **135**, remote site ADC function **136**, snapshot function **137**, volume table **138**, and ADC setting table **138**. Remote site storage **104** further comprises inner storage network **140**, data volume **141**, journal volume **141**, and backup volume **143**.

[0040] In operation, APG-ADC configuration function **110** obtains, from at least one of VM/container manager **111** or TP monitor **112**, application group information, such as volume data information that associates containers with volumes. APG-ADC configuration function **110** further obtains an appropriate remote site from destination selection function **113**. Main site ADC function **125** writes incoming data to data volume **130** and creates journal volume **131**, e.g., to update a log in journal volume **131**, which corresponds to journal volume **142** in remote site storage **104**.

[0041] Remote site ADC function **136** applies a log to data volume **141** in remote site storage **104**. Snapshot function **137** is a consistent backup in backup volume **143** by halting a volume update and then using a journal log to copy data from data volume **141** to backup volume **143** prior to resuming the volume update.

[0042] FIG. **2** depicts an example of the VM/container setting table shown in FIG. **1**. VM/container setting table **114** stores volume data information that identifies which container **201** (denoted as VM/pod ID) having a certain name **202** (denoted as VM/Pod name) uses which volume **203** (denoted as related volumes). The VM/pod ID **201** identifies a VM and pod. The VM/pod name **202** is the name of the VM and pod. The related volumes **203** denote data volumes that are used in the VM and pod. As depicted in FIG. **2**, a user may tag label **204** and create label value **205**. In FIG. **2**, VMs/pods **1** and **2** have labels **204** that are tagged as “consistent group.” The notation “CTG**1**” for label value **205** indicates that the VMs/pods DB**1** and DB**2** require data consistency among them.

[0043] FIG. **3** depicts an example of the business process table shown in FIG. **1**. Business process table **115** comprises columns for business process ID **301**, business process name **302**, and VM/pod IDs **303**. Business process ID **301** identifies a business process. Business process name **302** is the name of the business process. VM/pod IDs **303** specify those VMs and pods that are used for their respective business processes. In the example in FIG. **3**, a backup of business process “sales” requires a consistent backup of VM **1** and VM **2**, which, as indicated in FIG. **2**, uses volumes **1-3** that should be consistent.

[0044] FIG. **4** depicts an example of the network bandwidth table shown in FIG. **1**. It includes information about original site **401**, destination site **402**, and network bandwidth **403**. Network bandwidth **403** comprises information about the network bandwidth needed to transfer data from original site **401** and destination site **402**. As depicted, network bandwidth **403** for remote site **1** is 100 Mbps and network bandwidth **403** for remote site **2** is 200 Mbps. Advantageously, such data transfer information can be used to select an appropriate destination backup site.

[0045] FIG. **5** depicts an example of volume tables in the main and remote site storage shown in FIG. **1**. Volume tables **126** and **138** include volume **501**, device **502**, and address range **503**. The table in FIG. **5** specifies the device that stores data for the volume. For example, the data in volume **1** are stored at an address range from 0 to 1000 within flash device **1**.

[0046] FIG. **6** depicts an example of ADC setting tables in the main and remote site storage shown in FIG. **1**. Tables **127** and **139** specify the volume group of ADC and the journal volumes used for ADC, i.e., which volume group can use which journal volume to be asynchronously copied to a remote site. For example, in FIG. **6**, volumes **1** and **2** are asynchronously copied to a volume **101** and a volume **102** using journal volume **1** and journal volume **101**.

[0047] FIG. **7** depicts an example of the IO statistics table in the main site storage shown in FIG. **1**. Table **128** in FIG. **7** indicates that particular volumes **701**, volumes **1** and **2**, can be accessed at certain IO statistics **702**, here, throughput rates of 100 GB per hour and 200 GB per hour, respectively.

[0048] FIG. **8** illustrates an example of a graphical user interface (GUI) of the VM/container manager shown in FIG. **1**. A user may use the shown GUI for VM/container manager **111**, for example, to assign labels **803** and label values **804** to a VM/pod. In FIG. **8**, label **803**, denoted as “consistent group,” and label value **804**, denoted as “CTG**1**, end,” are associated with VM/pod “DB**1**.” As a result, the VM or pod DB**1** is assigned to the consistent group. The marker “end” indicates that all the VMs and pods in the group have already been labeled. These inputs are reflected in VM/container setting table **114** (shown in FIG. **1**).

[0049] FIG. **9** depicts an example of a GUI of the APG-ADC configuration function shown in FIG. **1**. APG-ADC configuration function **110** is displayed in the flowchart of FIG. **10**. As depicted in FIG. **9**, a user can click a button labeled “create asynchronous copy” to perform an action **902** such as communicating the instruction “create asynchronous copy,” to an ADC that is included in the VMs/pods in business process **901**.

[0050] FIG. **10** is a flowchart illustrating an example process for the APG-ADC configuration function shown in FIG. **1**. APG-ADC configuration function **110** displays, e.g., the GUI in FIG. **9**, and receives user input. Further, APG-ADC configuration function **110** receives notification of label changes from VM/container manager **111** (shown in FIG. **1**). The process in FIG. **10** starts, at step **1000**, with a dual VM-based input (left path) and an application-level input (right path).

[0051] For VM-based inputs, at step **1010**, a notice of label change is received from VM/container manager **111**. At step **1012**, labels of the same application group are obtained from

VM/container manager **111**. These group labels may have been user-configured and identify consistent groups. At step **1014**, it is determined whether the label value of the obtained label includes an end flag. If so, the process returns to start **1000**. Otherwise, the process resumes with step **1030**, at which related volumes **203** (shown in FIG. **2**) in the application group are obtained from VM/container manager **111**.

[0052] For the application-level inputs, at step **1020**, a request to create an asynchronous copy of a business process is received, e.g., from the GUI shown in FIG. **9**. VM and pod IDs related to the business process are obtained from TP monitor **112**, and the process resumes with step **1030**. At step **1032**, it is determined whether the system has multiple remote sites. If so, the system continues with step **1034**, at which a request to select an appropriate remote site as backup site, e.g., by using destination selection function **113**, is generated. Otherwise, the process directly resumes with step **1036**, at which the request to create a journal volume to the ADC configuration function **120** in storage management server **102** is generated. Finally, a request to generate an asynchronous copy of all related volumes using the journal volume to the ADC configuration function **120** is generated.

[0053] FIG. **11** is a flowchart illustrating an example process for the VM/container manager shown in FIG. **1**. The process in FIG. **11** starts, at step **1102**, when the VM/container manager **111** displays a GUI such as that shown in FIG. **8**, e.g., in response to receiving user input. At step **1104**, is determined whether all labels have changed by the user. If not, at step **1104**, the process returns to the GUI step **1102**. Otherwise, at step **1106**, a notification of the label change is communicated to APG-ADC configuration function **110**. And, at step **1108**, a notification of all the labels of the same group is communicated to APG-ADC configuration function **110**.

[0054] FIG. **12** is a flowchart illustrating an example process for the TP monitor shown in FIG. **1**. The process in FIG. **12** starts, at step **1202**, when the VM/container manager **111** displays a GUI such as that shown in FIG. **9**. At step **1204**, it is determined whether all labels have been changed by the user. If not, at step **1204**, the process returns to the GUI. Otherwise, at step **1206**, the TP monitor **112** communicated the business process to the APG-ADC configuration function **110**. And, at step **1208**, the TP monitor **112** communicates the related VM and pod IDs to the APG-ADC configuration function **110** which responds to the requests from the APG-ADC configuration function **110**.

[0055] FIG. **13** is a flowchart illustrating an example process for the destination selection function shown in FIG. **1**. Destination selection function **113** procedure starts at step **1302** when destination selection function **113** receives the list of volumes from APG-ADC configuration function **110**. In step **1304**, IO statistics of the related volumes are obtained from IO statistics **128**. At step **1306**, the IO statistics regarding related volumes are summed up. At step **1308**, the sum is compared with entries of the network bandwidth table **116**. Finally, at step **1310**, the destination site that has a larger bandwidth than that sum is communicated to APC-ADC configuration function **110**, such that destination selection function **113** can select a proper backup site based on backup rate and transfer rate.

[0056] FIG. **14** is a flowchart illustrating an example process for the ADC configuration function shown in FIG. **1**. The process for ADC configuration function **120** in storage management server **102** starts, at step **1402**, when ADC configuration function **120** receives a request to create journal volumes from APG-ADC configuration function **110** in system management server **101**. At step **1404**, ADC configuration function **120** receives a request to create journal volumes in main site storage **103** and remote site storage **104** and to register them to respective volume tables **126** and **138**. At step **1406**, ADC configuration function **120** receives a request to create an asynchronous copy of all related volumes using the journal volume from APG-ADC configuration function **110**. At step **1408**, ADC entries for all related volumes are added to ADC setting tables **127** and **139** in main site storage **103** and remote site storage **104**, respectively.

[0057] FIG. **15** is a flowchart illustrating an example process for the IO control function **124**. The process for IO control function **124** starts at step **1502** when IO control function **124** receives either a read data request or a write data request from a user. For read data requests, at step **1504**, the target read data is specified using volume table **126**. At step **1506**, the target data is read from devices and returned at step **1508**. For write data requests, at step **1510**, the target device is specified using volume table **126**. At step **1512**, the data is written to the target device. At step **1514**, it is determined whether the target volume is included in ADC setting table **127**. If so, at step **1516**, the data write is communicated to the main site ADC function **125**, and the process continues with step **1518**, when a message indicating the completion of the data right is returned. If at step **1514**, it is determined that the target volume is not included in ADC setting table **127**, the process directly returns the completion message at step **1518**, e.g., such that ADC function **125** can update journal volume **131** shown in FIG. **1**.

[0058] FIG. **16** is a flowchart illustrating an example process for the main site ADC function shown in FIG. **1**. The process for main site ADC function **125** starts at step **1602** when the main site ADC function receives the notification of the data write from IO control function **124**. At step **1604**, a journal entry is appended to journal volume **131**, shown in FIG. **17**.

[0059] FIG. **17** illustrates an example of journal entries stored in a journal volume. Journal volume **131** is generated by main site ADC function **125** (both shown in FIG. **1**). As depicted, Journal volume **131** comprises columns sequence number, volume name, volume address, and the written data.

[0060] FIG. **18** is a flowchart illustrating an example process for the remote site ADC function shown in FIG. **1**. The process for remote site ADC function **136** starts at step **1802**, e.g., periodically every 1 or 10 seconds, when the journal entry is copied from journal volume **131** site storage **103** to journal volume **142** in remote site storage **104**. At step **1804**, it is determined whether new journal entries exist. If so, data volumes **141** are updated according to the new journal entries, where the correspondence of the data volumes is indicated in the ADC setting table **139** and the process ends at step **1808**. Otherwise, if no new journal entries exist at step **1804**, the process directly ends at step **1808**.

[0061] FIG. **19** is a flowchart illustrating an example process for the snapshot function shown in FIG. **1**. The process for snapshot function **137** starts at step **1902** when snapshot function **137** suspends the data update of the remote side ADC function **136**. At step **1904**, all the data from data volume **141** are copied to backup volume **143**. At step **1906**, the process resumes with a data update of the remote site ADC function **136**.

[0062] FIG. **20** illustrates an example computing environment with an example computer device suitable for use in some example implementations, such as system management server **101**, storage management server **102**, main site storage **103**, remote site storage **104**, system network **105**, and storage network **106** shown in FIG. **1**.

[0063] Computer device **2005** in computing environment **2000** can include one or more processing units, cores, or processors **2010**, memory **2015** (e.g., RAM, ROM, and/or the like), internal storage **2020** (e.g., magnetic, optical, solid-state storage, and/or organic), and/or I/O interface **2025**, any of which can be coupled on a communication mechanism or bus **2030** for communicating information or embedded in the computer device **2005**. I/O interface **2025** is also configured to receive images from cameras or provide images to projectors or displays, depending on the desired implementation.

[0064] Computer device **2005** can be communicatively coupled to input/user interface **2035** and output device/interface **2040**. Either one or both of input/user interface **2035** and output device/interface **2040** can be a wired or wireless interface and can be detachable. Input/user interface **2035** may include any device, component, sensor, or interface, physical or virtual, that can be used to provide input (e.g., buttons, touch-screen interface, keyboard, a pointing/cursor control, microphone, camera, braille, motion sensor, optical reader, and/or the like). Output device/interface **2040** may include a display, television, monitor, printer, speaker, braille, or the like. In some example implementations, input/user interface **2035** and output device/interface **2040** can be embedded with or physically coupled to the computer device **2005**. In other example implementations, other computer devices may function as or provide the functions of input/user interface **2035** and output device/interface **2040** for a computer device **2005**.

[0065] Examples of computer device **2005** may include, but are not limited to, highly mobile devices (e.g., smartphones, devices in vehicles and other machines, devices carried by humans and animals, and the like), mobile devices (e.g., tablets, notebooks, laptops, personal computers, portable televisions, radios, and the like), and devices not designed for mobility (e.g., desktop computers, other computers, information kiosks, televisions with one or more processors embedded therein and/or coupled thereto, radios, and the like).

[0066] Computer device **2005** can be communicatively coupled (e.g., via I/O interface **2025**) to external storage **2045** and network **2050** for communicating with any number of networked components, devices, and systems, including one or more computer devices of the same or different configuration. Computer device **2005** or any connected computer device can be functioning as, providing services of, or referred to as a server, client, thin server, general machine, special-purpose machine, or another label.

[0067] I/O interface **2025** can include wired and/or wireless interfaces using any communication or I/O protocols or standards (e.g., Ethernet, 802.11x, Universal System Bus, WiMax, modem, a cellular network protocol, and the like) for communicating information to and/or from at least all the connected components, devices, and network in computing environment **2000**. Network **2050** can be any network or combination of networks (e.g., the Internet, local area network, wide area network, a telephonic network, a cellular network, a satellite network, and the like).

[0068] Computer device **2005** can use and/or communicate using computer-usable or computer-readable media, including transitory media and non-transitory media. Transitory media include transmission media (e.g., metal cables, fiber optics), signals, carrier waves, and the like. Non-transitory media include magnetic media (e.g., disks and tapes), optical media (e.g., CD ROM, digital video disks, Blu-ray disks), solid-state media (e.g., RAM, ROM, flash memory, solid-state storage), and other non-volatile storage or memory.

[0069] Computer device **2005** can be used to implement techniques, methods, applications, processes, or computer-executable instructions in some example computing environments. Computer-executable instructions can be retrieved from transitory media, and stored on and retrieved from non-transitory media. The executable instructions can originate from one or more of any programming, scripting, and machine languages (e.g., C, C++, C #, Java, Visual Basic, Python, Perl, JavaScript, and others).

[0070] Processor(s) **2010** can execute under any operating system (OS) (not shown), in a native or virtual environment. One or more applications can be deployed that include logic unit **2060**, application programming interface (API) unit **2065**, input unit **2070**, output unit **2075**, and inter-unit communication mechanism **2095** for the different units to communicate with each other, with the OS, and with other applications (not shown). The described units and elements can be varied in design, function, configuration, or implementation and are not limited to the descriptions provided. Processor(s) **2010** can be in the form of hardware processors such as central processing units (CPUs) or in a combination of hardware and software units.

[0071] In some example implementations, when information or an execution instruction is received by API unit **2065**, it may be communicated to one or more other units (e.g., logic unit **2060**, input unit **2070**, output unit **2075**). In some instances, logic unit **2060** may be configured to control the information flow among the units and direct the services provided by API unit **2065**, input unit **2070**, output unit **2075**, in some example implementations described above. For example, the flow of one or more processes or implementations may be controlled by logic unit **2060** alone or in conjunction with API unit **2065**. The input unit **2070** may be configured to obtain input for the calculations described in the example implementations, and the output unit **2075** may be configured to provide output based on the calculations described in example implementations.

[0072] Processor(s) **2010** can be configured to execute a method or computer instructions which can involve, performing steps of an APG-ADC configuration function as described with reference to FIG. **10**; steps of a VM/container manager, as described with reference to FIG. **11**; steps of a TP monitor, as described with reference to FIG. **12**; steps of a destination selection function, as described with reference to FIG. **13**; steps of an ADC configuration function, as described with reference to FIG. **14**; steps of an IO control function, as described with reference to FIG. **15**; steps of a main site ADC function, as described with reference to FIG. **16**; steps of a remote site ADC function, as described with reference to FIG. **18**; and steps of a snapshot function, as described with reference to FIG. **19**.

[0073] Processor(s) **2010** can be configured to execute an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

[0074] Depending on the desired implementation, the input of the application group information can be provided from a group of virtual machines and containers obtained from a virtual machine/container manager that is configured to manage the virtual machines and the containers in the primary site.

[0075] Depending on the desired implementation, the input of the application group information is provided from an executed process obtained from an executed transaction processing monitor configured to manage the executed process with virtual machines and containers in the primary site.

[0076] Depending on the desired implementation, the asynchronous copying can be set through a primary site ADC configuration function executed on one or more storage devices of the primary site and a remote site ADC configuration function executed on the one or more storage devices in the remote site, wherein the primary site ADC configuration function is configured to conduct a data update in a consistent group to a journal volume in the primary site, and wherein the remote site ADC configuration function updates data volumes in the remote site according to an journal entry in the journal volume.

[0077] Depending on the desired implementation, the backup volumes are created by a snapshot function configured to suspend the data update of the remote site ADC function and copy data volumes to backup volumes.

[0078] Depending on the desired implementation, a copy destination is selected by a destination select function, which selects the destination through comparing a sum of data throughput of consistent group and network bandwidth between the primary site and the remote site.

[0079] Some portions of the detailed description are presented in terms of algorithms and symbolic representations of operations within a computer. These algorithmic descriptions and symbolic representations are the means used by those skilled in the data processing arts to convey the essence of their innovations to others skilled in the art. An algorithm is a series of defined steps leading to a desired end state or result. In example implementations, the steps carried out require physical manipulations of tangible quantities for achieving a tangible result.

[0080] Unless specifically stated otherwise, as apparent from the discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing," "computing," "calculating," "determining," "displaying," or the like, can include the actions and processes of a computer system or other information processing device that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system's memories or registers or other information storage, transmission or display devices.

[0081] Example implementations may also relate to an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, or it may include one or more general-purpose computers selectively activated or reconfigured by one or more computer programs. Such computer programs may be stored in a computer-readable medium, such as a computer-readable storage medium or a computer-readable signal medium. A computer-readable storage medium may involve tangible mediums such as, but not limited to optical disks, magnetic disks, read-only memories, random access memories, solid-state devices and drives, or any other types of tangible or non-transitory media suitable for storing electronic information. A computer-readable signal medium may include mediums such as carrier waves. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Computer programs can involve pure software implementations that involve instructions that perform the operations of the desired implementation.

[0082] Various general-purpose systems may be used with programs and modules in accordance with the examples herein, or it may prove convenient to construct a more specialized apparatus to perform desired method steps. In addition, the example implementations are not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the techniques of the example implementations as described herein. The instructions of the programming language(s) may be executed by one or more processing devices, e.g., central processing units (CPUs), processors, or controllers.

[0083] As is known in the art, the operations described above can be performed by hardware, software, or some combination of software and hardware. Various aspects of the example implementations may be implemented using circuits and logic devices (hardware), while other aspects may be implemented using instructions stored on a machine-readable medium (software), which if executed by a processor, would cause the processor to perform a method to carry out implementations of the present application. Further, some example implementations of the present application may be performed solely in hardware, whereas other example implementations may be performed solely in software. Moreover, the various functions described can be performed in a single unit, or can be spread across a number of components in any number of ways. When performed by software, the methods may be executed by a processor, such as a general-purpose computer, based on instructions stored on a computer-readable medium. If desired, the instructions can be stored on the medium in a compressed and/or encrypted format.

[0084] Moreover, other implementations of the present application will be apparent to those skilled in the art from consideration of the specification and practice of the techniques of the present application. Various aspects and/or components of the described example implementations may be used singly or in any combination. It is intended that the specification and example implementations be considered as examples only, with the true scope and spirit of the present application being indicated by the following claims.

What is claimed is:

1. A system for copying data from a primary site including one or more server devices and one or more storage devices to a secondary site including one or more storage devices using asynchronous copying, the system comprising:

a processor at the one or more server devices, configured to execute an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

2. The system of claim **1**, wherein the input of the application group information is provided from a group of virtual machines and containers obtained from a virtual machine/container manager that is configured to manage the virtual machines and the containers in the primary site.

3. The system of claim **1**, wherein the input of the application group information is provided from an executed process obtained from an executed transaction processing monitor configured to manage the executed process with virtual machines and containers in the primary site.

4. The system of claim **1**, wherein the asynchronous copying is set through a primary site ADC configuration function executed on one or more storage devices of the primary site and a remote site ADC configuration function executed on the one or more storage devices in the remote site, wherein the primary site ADC configuration function is configured to conduct a data update in a consistent group to a journal volume in the primary site, and wherein the remote site ADC configuration function updates data volumes in the remote site according to an journal entry in the journal volume.

5. The system of claim **4**, wherein backup volumes are created by a snapshot function configured to suspend the data update of the remote site ADC function and copy data volumes to backup volumes.

6. The system of claim **5**, wherein a copy destination is selected by a destination select function, which selects the destination through comparing a sum of data throughput of consistent group and network bandwidth between the primary site and the remote site.

7. A method for copying data from a primary site including one or more server devices and one or more storage devices to a secondary site including one or more storage devices using asynchronous copying, the method comprising:

executing an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

8. The method of claim **7**, wherein the input of the application group information is provided from a group of virtual machines and containers obtained from a virtual machine/container manager that is configured to manage the virtual machines and the containers in the primary site.

9. The method of claim **7**, wherein the input of the application group information is provided from an executed process obtained from an executed transaction processing monitor configured to manage the executed process with virtual machines and containers in the primary site.

10. The method of claim **7**, wherein the asynchronous copying is set through a primary site ADC configuration function executed on one or more storage devices of the primary site and a remote site ADC configuration function executed on the one or more storage devices in the remote site, wherein the primary site ADC configuration function is configured to conduct a data update in a consistent group to a journal volume in the primary site, and wherein the remote site ADC configuration function updates data volumes in the remote site according to an journal entry in the journal volume.

11. The method of claim **10**, wherein backup volumes are created by a snapshot function configured to suspend the data update of the remote site ADC function and copy data volumes to backup volumes.

12. The method of claim **11**, wherein a copy destination is selected by a destination select function, which selects the destination through comparing a sum of data throughput of consistent group and network bandwidth between the primary site and the remote site.

13. A non-transitory computer readable medium, storing instructions for copying data from a primary site including one or more server devices and one or more storage devices to a secondary site including one or more storage devices using asynchronous copying, the instructions comprising:

executing an application group asynchronous data copy (APG-ADC) configuration function that sets an asynchronous copying of group data from an input of application group information, wherein the APG-ADC configuration function sets the asynchronous copying of the grouped data so as to maintain an update order of the grouped data.

14. The non-transitory computer readable medium of claim **13**, wherein the input of the application group information is provided from a group of virtual machines and containers obtained from a virtual machine/container manager that is configured to manage the virtual machines and the containers in the primary site.

15. The non-transitory computer readable medium of claim **13**, wherein the input of the application group information is provided from an executed process obtained from an executed transaction processing monitor configured to manage the executed process with virtual machines and containers in the primary site.

16. The non-transitory computer readable medium of claim **13**, wherein the asynchronous copying is set through a primary site ADC configuration function executed on one or more storage devices of the primary site and a remote site ADC configuration function executed on the one or more storage devices in the remote site, wherein the primary site ADC configuration function is configured to conduct a data update in a consistent group to a journal volume in the primary site, and wherein the remote site ADC configuration function updates data volumes in the remote site according to an journal entry in the journal volume.

17. The non-transitory computer readable medium of claim **16** wherein backup volumes are created by a snapshot function configured to suspend the data update of the remote site ADC function and copy data volumes to backup volumes.

18. The non-transitory computer readable medium of claim **17**, wherein a copy destination is selected by a destination select function, which selects the destination through comparing a sum of data throughput of consistent group and network bandwidth between the primary site and the remote site.

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