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(54) **DATA MIGRATION USING A CONSISTENCY GROUP**

(71) Applicant: **HEWLETT PACKARD ENTERPRISE DEVELOPMENT LP**, Spring, TX (US)

(72) Inventors: **Murali Vaddagiri**, Austin, TX (US); **Krishna Karoor Kumar**, San Jose, CA (US); **Joseph Raymond Loos**, San Jose, CA (US)

(73) Assignee: **Hewlett Packard Enterprise Development LP**, Spring, TX (US)

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G06F 16/27 (2019.01)
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G06F 16/23 (2019.01)

(52) **U.S. Cl.**
CPC ***G06F 16/27*** (2019.01); ***G06F 16/214*** (2019.01); ***G06F 16/2365*** (2019.01)

(58) **Field of Classification Search**
CPC G06F 16/27; G06F 16/214; G06F 16/2365
See application file for complete search history.

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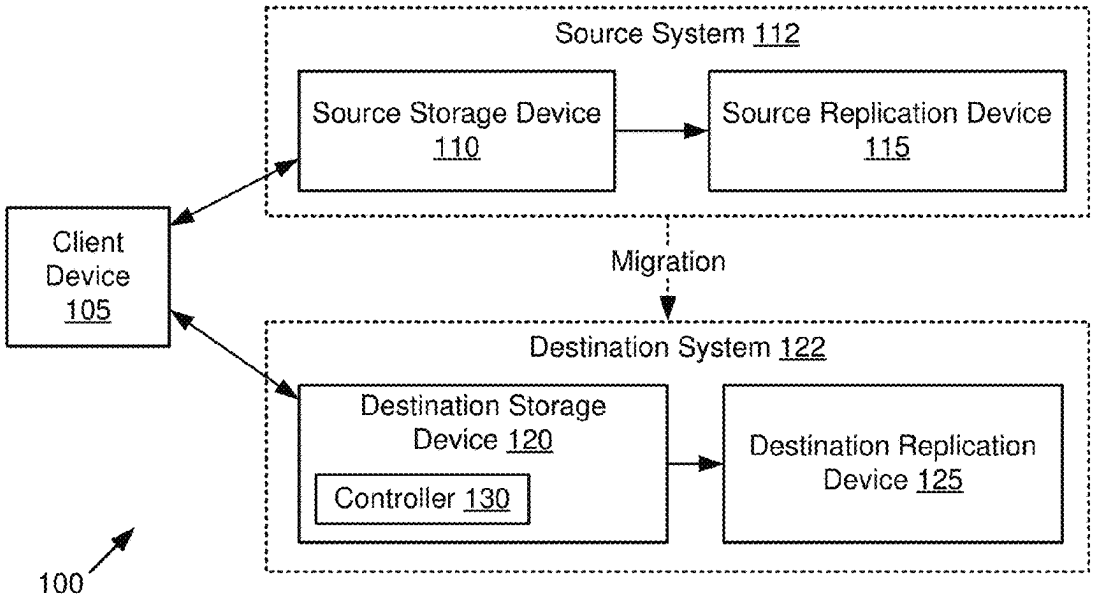
Primary Examiner — Tony Wu
(74) *Attorney, Agent, or Firm* — Trop, Pruner & Hu, P.C.

(57) **ABSTRACT**

Example implementations relate to computer data storage. In some examples, a controller establishes a migration link between a first storage device and a second storage device, and create a consistency group including replicating volumes and a control volume stored on the first storage device. The controller initiates, based on the consistency group, a data copy from the replicating volumes to proxy volumes on the second storage device. In response to a completion of the data copy from the replicating volumes to the proxy volumes, the controller initiates a replication of the proxy volumes to a second replication device. Further, in response to a completion of the replication of the proxy volumes, the controller transfers a copy of the control volume to the second storage device, where the transfer of the copy of the control volume completes the migration of the consistency group.

20 Claims, 8 Drawing Sheets



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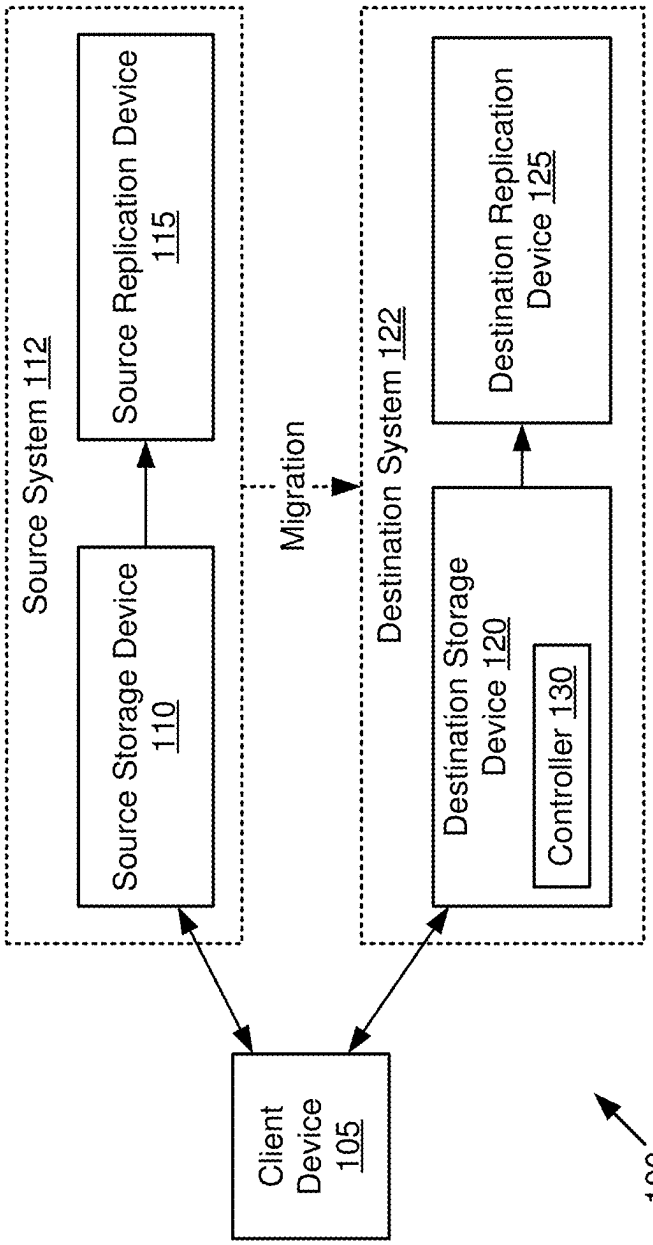
Source System 112
Source Storage Device 110
Source Replication Device 115
Migration
Destination System 122
Destination Storage Device 120
Controller 130
Destination Replication Device 125
Client Device 105
100

FIG. 1

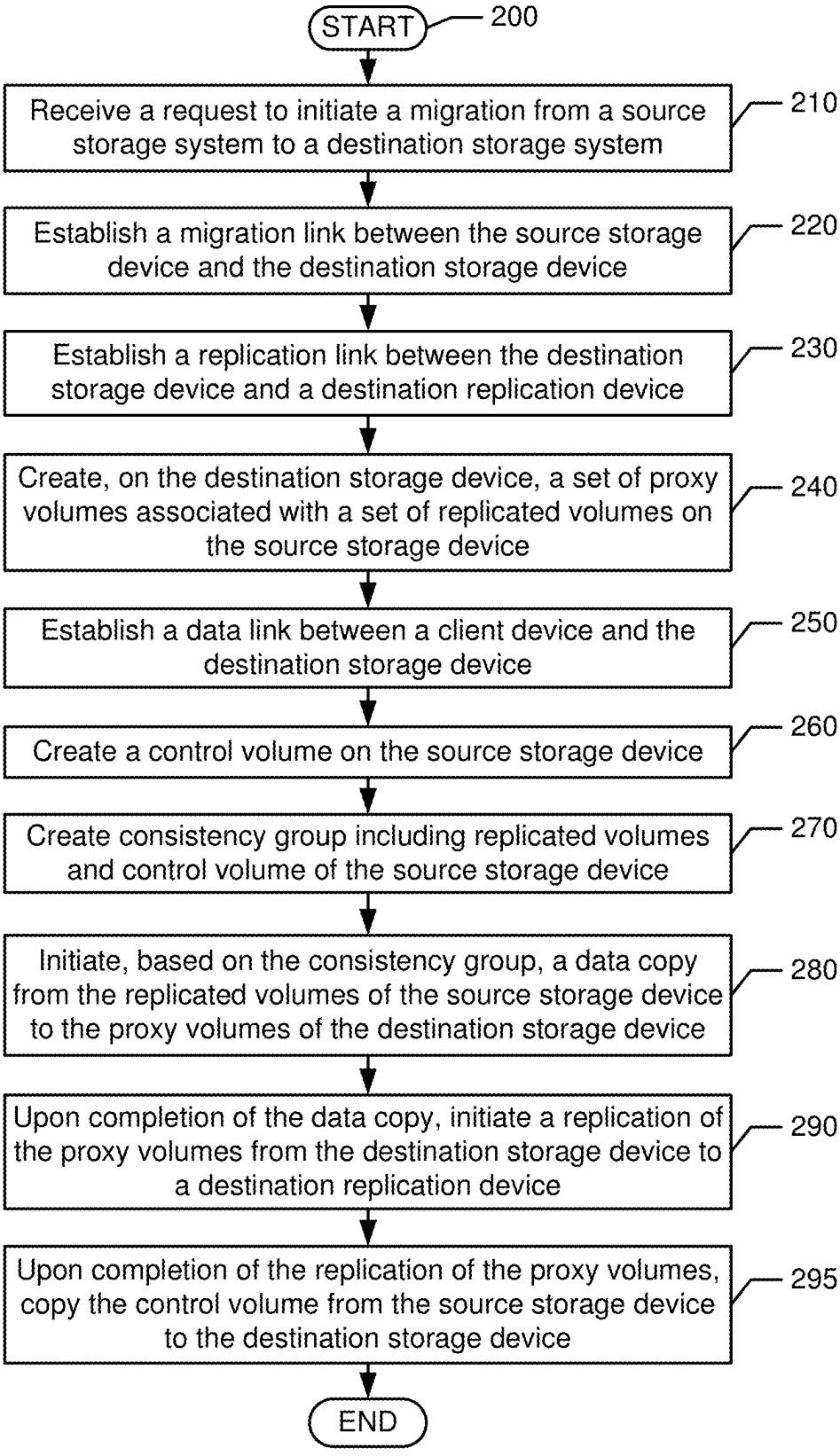
START
200
Receive a request to initiate a migration from a source storage system to a destination storage system
210
Establish a migration link between the source storage device and the destination storage device
220
Establish a replication link between the destination storage device and a destination replication device
230
Create, on the destination storage device, a set of proxy volumes associated with a set of replicated volumes on the source storage device
240
Establish a data link between a client device and the destination storage device
250
Create a control volume on the source storage device
260
Create consistency group including replicated volumes and control volume of the source storage device
270
Initiate, based on the consistency group, a data copy from the replicated volumes of the source storage device to the proxy volumes of the destination storage device
280
Upon completion of the data copy, initiate a replication of the proxy volumes from the destination storage device to a destination replication device
290
Upon completion of the replication of the proxy volumes, copy the control volume from the source storage device to the destination storage device
295
END

FIG. 2

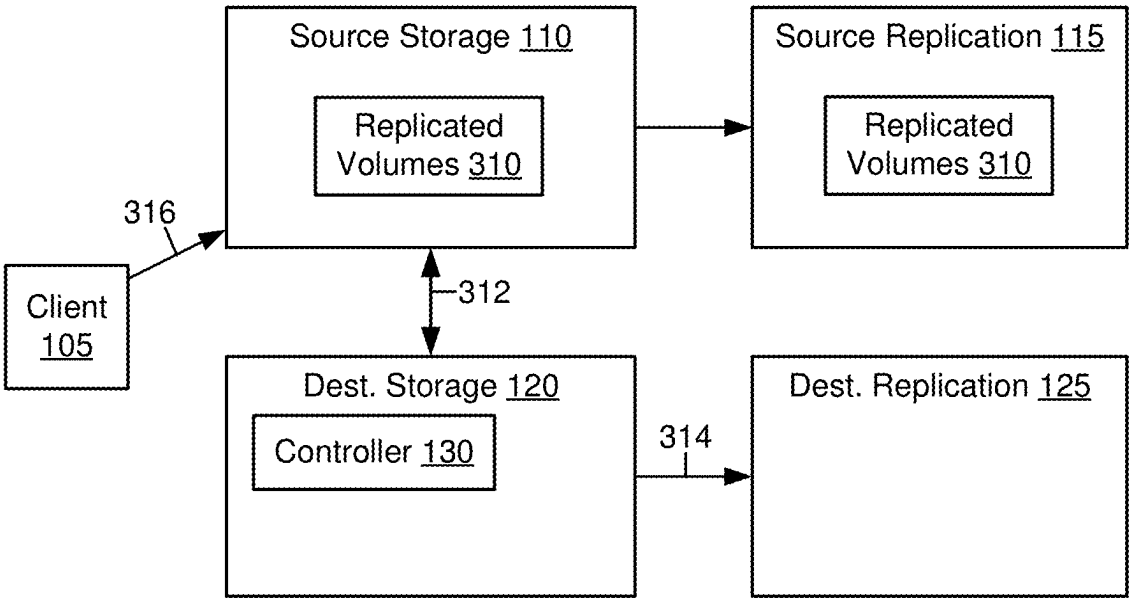
Source Storage 110
Replicated Volumes 310
Source Replication 115
Replicated Volumes 310
316
Client 105
312
Dest. Storage 120
Controller 130
314
Dest. Replication 125

FIG. 3A

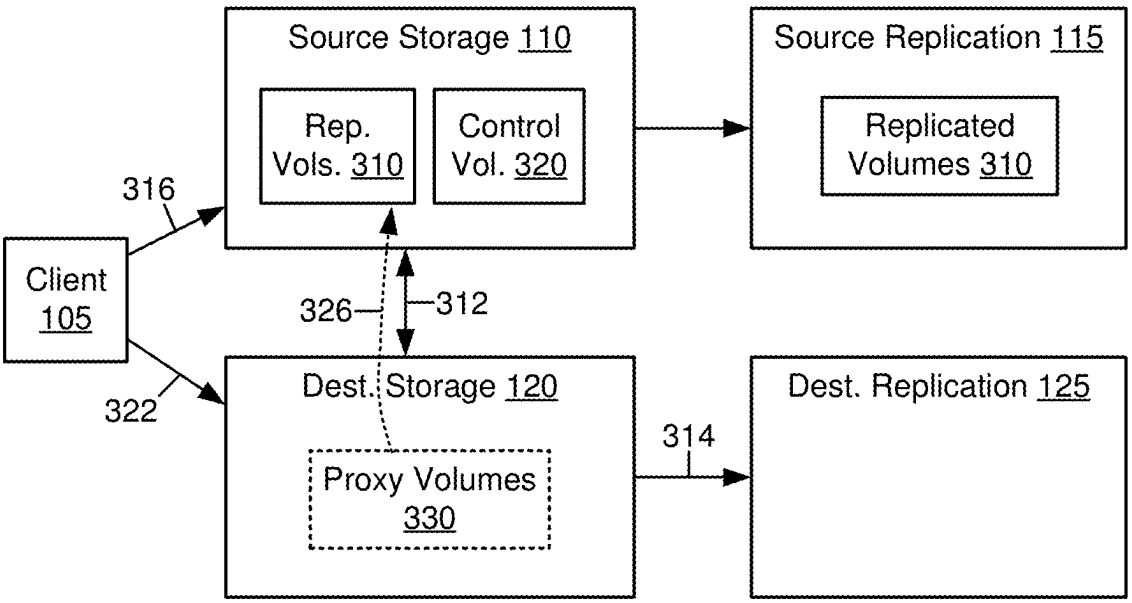
Source Storage 110
Rep. Vols. 310
Control Vol. 320
Source Replication 115
Replicated Volumes 310
316
Client 105
326
312
322
Dest. Storage 120
Proxy Volumes 330
314
Dest. Replication 125

FIG. 3B

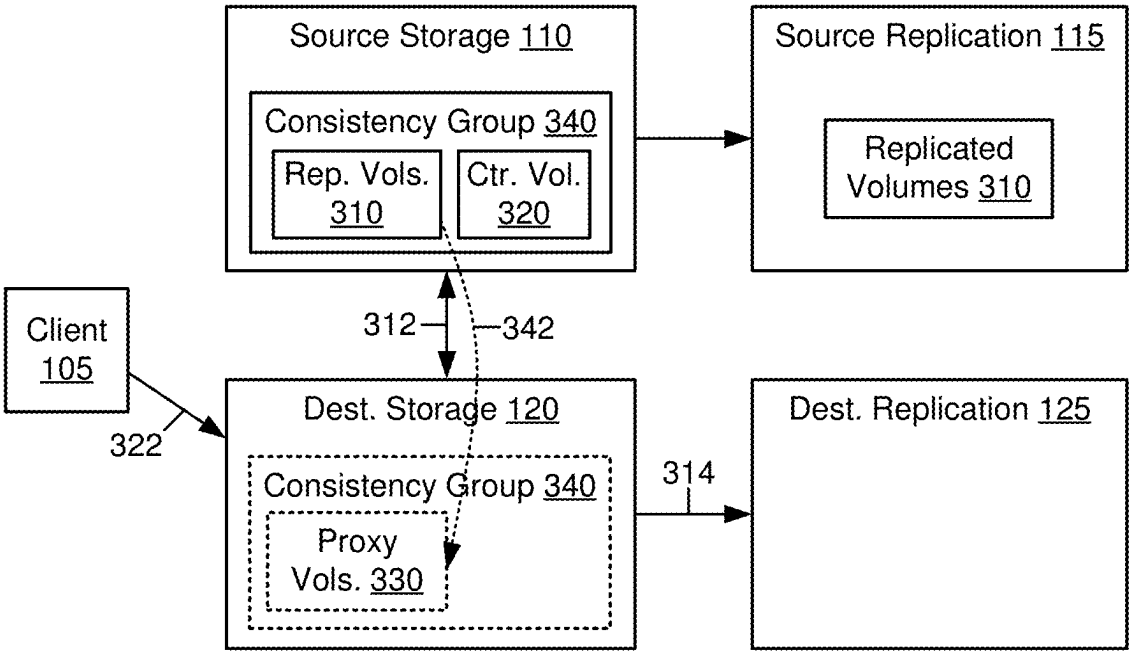
Source Storage 110
Consistency Group 340
Rep. Vols. 310
Ctr. Vol. 320
Source Replication 115
Replicated Volumes 310
Client 105
312
342
322
Dest. Storage 120
Consistency Group 340
Proxy Vols. 330
314
Dest. Replication 125

FIG. 3C

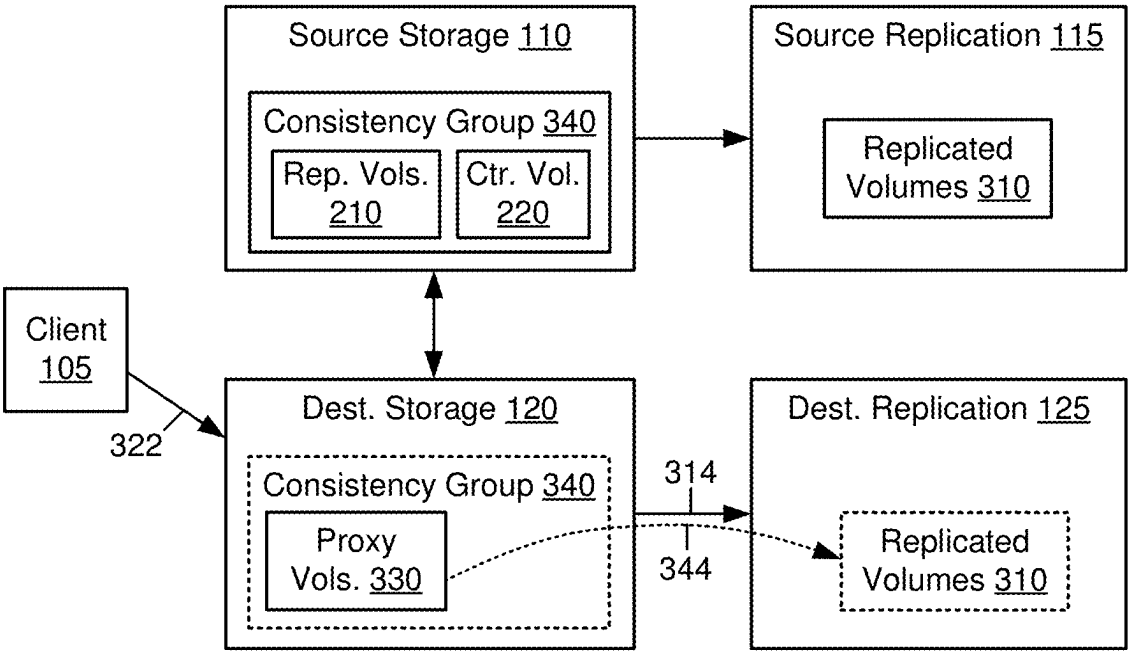
Source Storage 110
Consistency Group 340
Rep. Vols. 210
Ctr. Vol. 220
Source Replication 115
Replicated Volumes 310
Client 105
322
Dest. Storage 120
Consistency Group 340
Proxy Vols. 330
314
344
Dest. Replication 125
Replicated Volumes 310

FIG. 3D

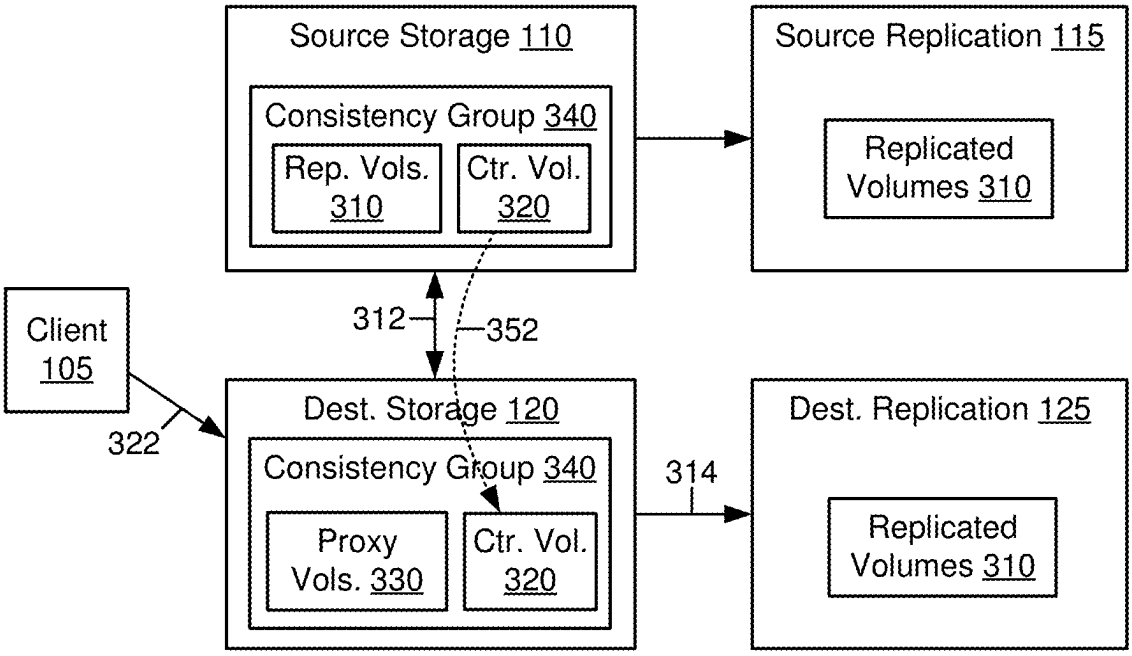
Source Storage 110
Consistency Group 340
Rep. Vols. 310
Ctr. Vol. 320
Source Replication 115
Replicated Volumes 310
312
352
Client 105
322
Dest. Storage 120
Consistency Group 340
Proxy Vols. 330
Ctr. Vol. 320
314
Dest. Replication 125
Replicated Volumes 310

FIG. 3E

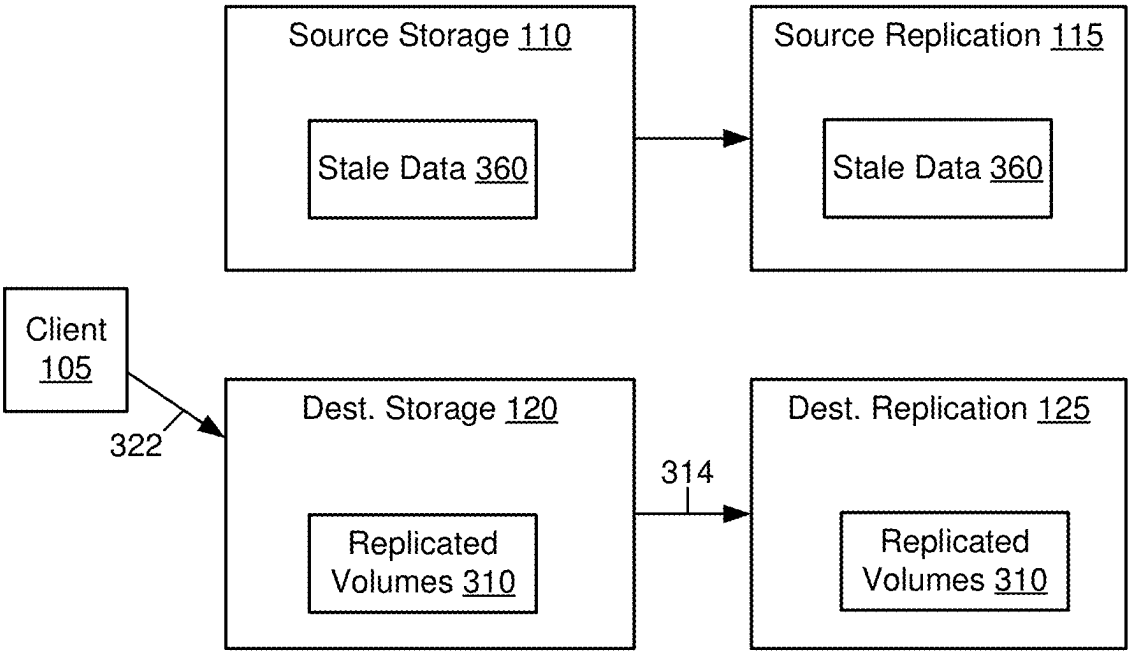
Source Storage 110
Stale Data 360
Source Replication 115
Stale Data 360
Client 105
322
Dest. Storage 120
Replicated Volumes 310
314
Dest. Replication 125
Replicated Volumes 310

FIG. 3F

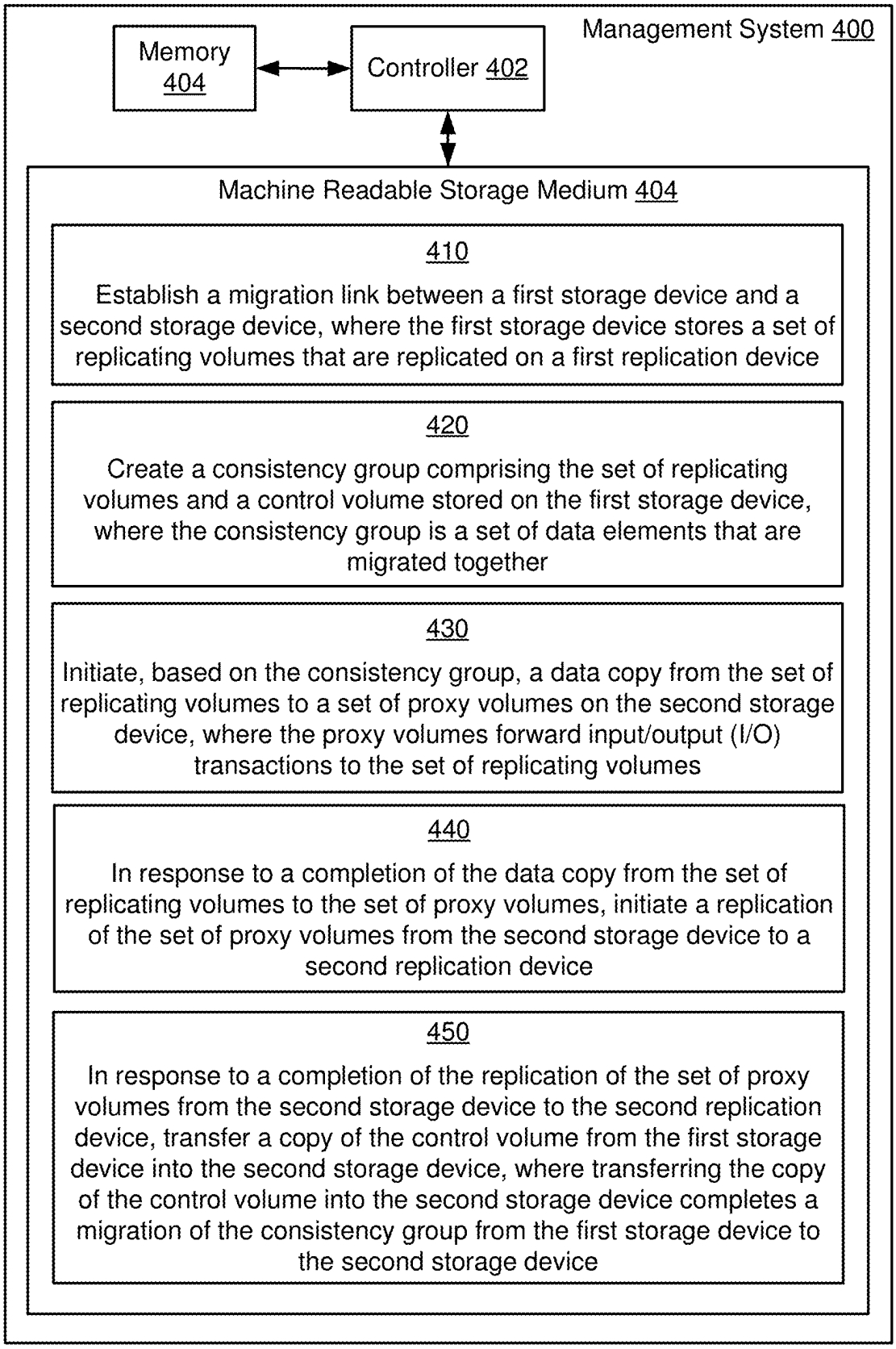
Management System 400
Memory 404
Controller 402
Machine Readable Storage Medium 404
410
Establish a migration link between a first storage device and a second storage device, where the first storage device stores a set of replicating volumes that are replicated on a first replication device
420
Create a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, where the consistency group is a set of data elements that are migrated together
430
Initiate, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, where the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes
440
In response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiate a replication of the set of proxy volumes from the second storage device to a second replication device
450
In response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transfer a copy of the control volume from the first storage device into the second storage device, where transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device

FIG. 4

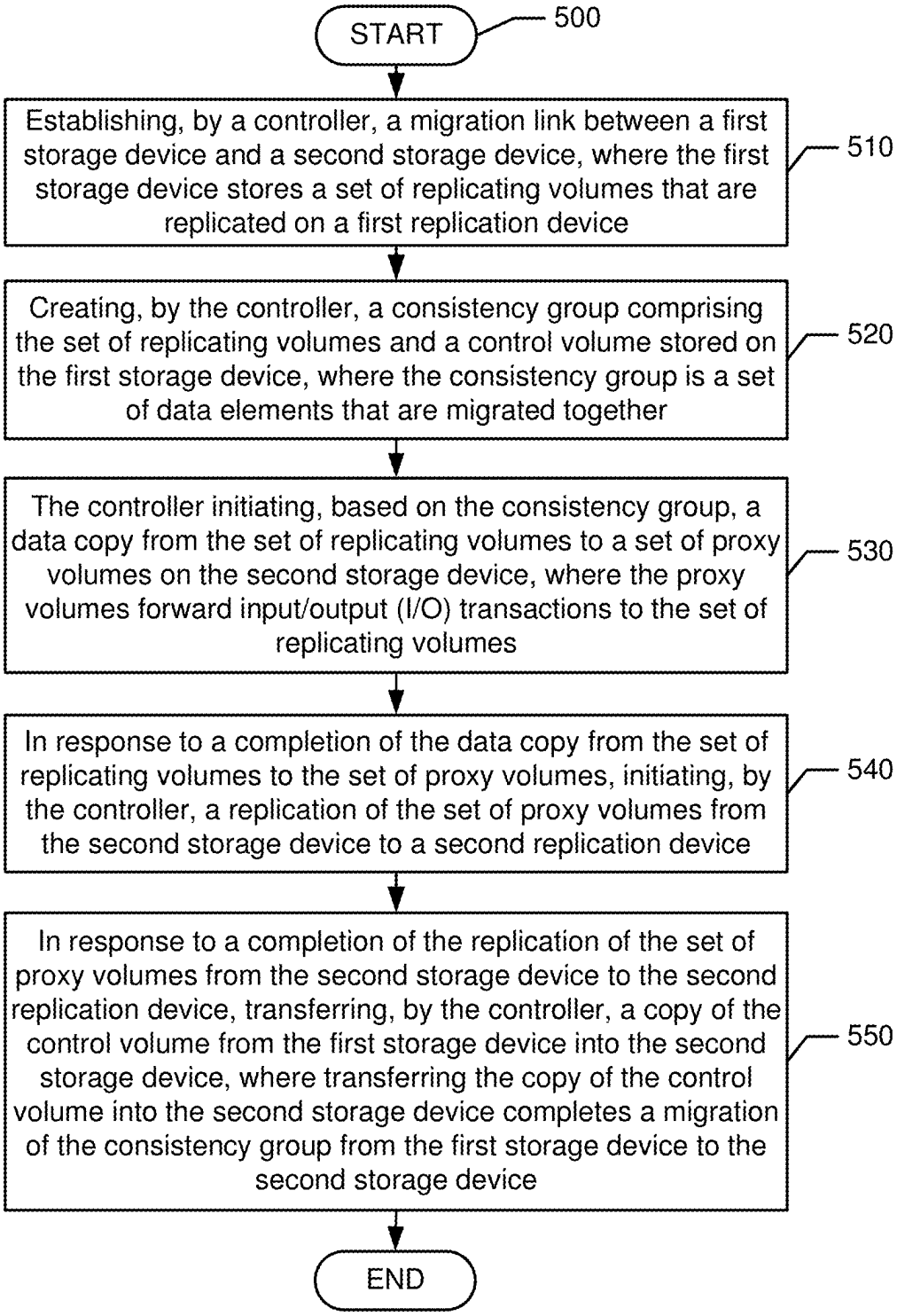
START
500
Establishing, by a controller, a migration link between a first storage device and a second storage device, where the first storage device stores a set of replicating volumes that are replicated on a first replication device
510
Creating, by the controller, a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, where the consistency group is a set of data elements that are migrated together
520
The controller initiating, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, where the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes
530
In response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiating, by the controller, a replication of the set of proxy volumes from the second storage device to a second replication device
540
In response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transferring, by the controller, a copy of the control volume from the first storage device into the second storage device, where transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device
550
END

FIG. 5

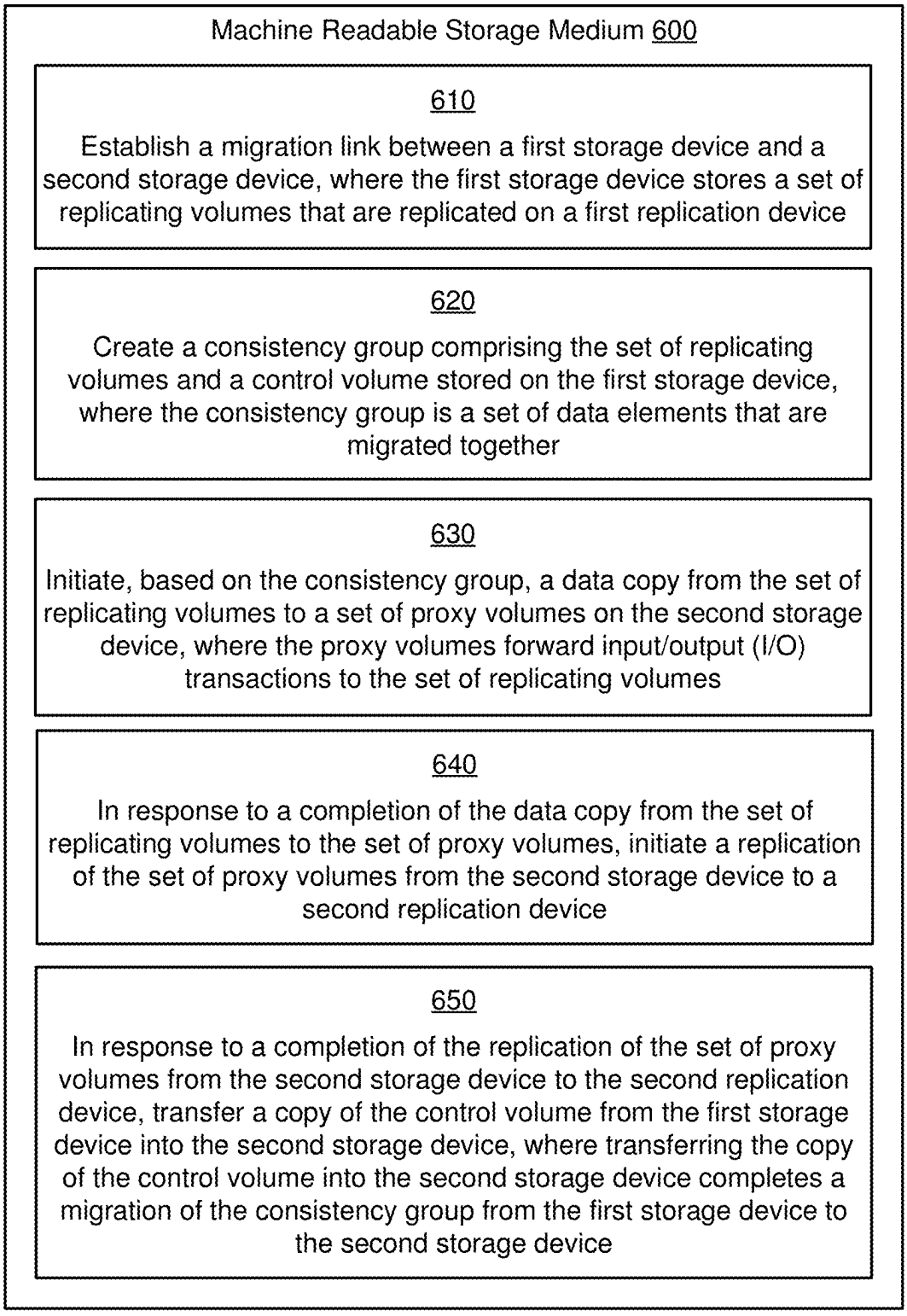
Machine Readable Storage Medium 600
610
Establish a migration link between a first storage device and a second storage device, where the first storage device stores a set of replicating volumes that are replicated on a first replication device
620
Create a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, where the consistency group is a set of data elements that are migrated together
630
Initiate, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, where the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes
640
In response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiate a replication of the set of proxy volumes from the second storage device to a second replication device
650
In response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transfer a copy of the control volume from the first storage device into the second storage device, where transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device

FIG. 6

DATA MIGRATION USING A CONSISTENCY GROUP

BACKGROUND

Computing devices may include components such as a processor, memory, caching system, and storage device. The storage device may include a hard disk drive that uses a magnetic medium to store and retrieve data blocks. Some storage systems may transfer data between different locations or devices. For example, some systems may transfer and store copies of important data for archival and recovery purposes.

BRIEF DESCRIPTION OF THE DRAWINGS

Some implementations are described with respect to the following figures.

FIG. **1** is a schematic diagram of an example system, in accordance with some implementations.

FIG. **2** is an illustration of an example process, in accordance with some implementations.

FIGS. **3A-3F** are illustration of example operations, in accordance with some implementations.

FIG. **4** is a schematic diagram of an example management system, in accordance with some implementations.

FIG. **5** is an illustration of an example process, in accordance with some implementations.

FIG. **6** is a diagram of an example machine-readable medium storing instructions in accordance with some implementations.

Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements. The figures are not necessarily to scale, and the size of some parts may be exaggerated to more clearly illustrate the example shown. Moreover, the drawings provide examples and/or implementations consistent with the description; however, the description is not limited to the examples and/or implementations provided in the drawings.

DETAILED DESCRIPTION

In the present disclosure, use of the term "a," "an," or "the" is intended to include the plural forms as well, unless the context clearly indicates otherwise. Also, the term "includes," "including," "comprises," "comprising," "have," or "having" when used in this disclosure specifies the presence of the stated elements, but do not preclude the presence or addition of other elements.

As used herein, a "storage system" can include a storage device or an array of storage devices. A storage system may also include storage controller(s) that manage(s) access of the storage device(s). A "data unit" can refer to any portion of data that can be separately identified in the storage system. In some cases, a data unit can refer to a chunk, a collection of chunks, or any other portion of data. In some examples, a storage system may store data units in persistent storage. Persistent storage can be implemented using one or more of persistent (e.g., nonvolatile) storage device(s), such as disk-based storage device(s) (e.g., hard disk drive(s) (HDDs)), solid state device(s) (SSDs) such as flash storage device(s), or the like, or a combination thereof. As used herein, a "controller" can refer to a hardware processing circuit, which can include any or some combination of a microprocessor, a core of a multi-core microprocessor, a microcontroller, a programmable integrated circuit, a programmable gate array, a digital signal processor, or another hardware processing circuit. Alternatively, a "controller" can refer to a combination of a hardware processing circuit and machine-readable instructions (software and/or firmware) executable on the hardware processing circuit.

In some examples, a collection of input data (e.g., a stream of real-time data values) may be persistently stored on a storage system. The storage system may include two (or more) storage devices that store duplicate copies of the data. For example, the storage system may include a first storage array that stores a copy of a collection of data, and may also include a second storage array that stores a duplicate copy of the collection of data stored on the first storage array. In this manner, data that is valuable or mission-critical (e.g., banking transaction data) may be protected against loss in the event of the failure of a single device or array.

In some examples, an existing storage system may be replaced with a different storage system (e.g., a newer storage system with improved storage capacity, data throughput, data security, etc.). This replacement process may include migrating the data stored on the existing storage system to the different storage system. However, the two storage systems may not be capable of performing the data migration without interruption of the normal storage functionality. For example, the two storage systems may be provided by different vendors (or may use different product lines or device generations from a same vendor), and may lack compatible functionality to perform a data migration while also receiving new input data and maintaining full replication of the stored data. Therefore, in such examples, performing the data migration may involve interrupting the receipt of new input data, and/or not maintaining full replication of the stored data during the entire period of the data migration. Accordingly, in such examples, performing the data migration may negatively impact the reliability and performance of one or both of the storage systems.

In accordance with some implementations of the present disclosure, a controller may perform a migration process to replace an existing ("source") storage system with a different ("destination") storage system. The source storage system and the destination storage system may each include a primary storage device and a secondary replication device. In some implementations, the migration process may include defining a consistency group that includes all replicated volumes on the source storage device (i.e., the volumes that are replicated to the source replication device), and also includes a dummy control volume that has no data content. The migration process may also include transferring the replicated volumes from the source storage device to the destination storage device, and initiating a data replication from the destination storage device to the destination replication device. Further, after completing the data replication, the migration process may include transferring the control volume from the source storage device to the destination storage device, thereby completing the migration of the consistency group. In this manner, the migration process may be completed while maintaining data storage and replication. Various aspects of the disclosed migration process are discussed further below with reference to FIGS. **1-6**.

FIG. **1**—Example System

FIG. **1** shows an example system **100**, in accordance with some implementations. The system **100** may include a client device **105**, a source system **112**, and a destination system **122**. The source system **112** may include a source storage device **110** and a source replication device **115**. In some implementations, the source storage device **110** may receive

data from the client device **105**, and may persistently store the received data. Further, some or all of the data stored on the source storage device **110** may be copied or "replicated" to be persistently stored on the source replication device **115**. For example, the source storage device **110** may store data in a set of volumes (e.g., logical storage units) that are automatically replicated to the source replication device **115** (also referred to herein as "replicated volumes"). In this manner, the data received from the client device **105** may be persistently stored in two different storage devices **110**, **115**, and may thus be protected against loss due to the failure of one of the two storage devices **110**, **115**.

In some implementations, the source system **112** may be replaced by the destination system **122** that includes a destination storage device **120** and a destination replication device **125**. For example, the owner or manager of the system **100** may determine that the source system **112** is an older storage system that does not meet a set of requirements (e.g., based on storage capacity, data throughput, data security, etc.), and may therefore replace the source system **112** with the newer destination system **122** that is capable of satisfying the set of requirements. In some examples, the source system **112** and the destination system **122** may be provided by different vendors, or may use different product lines or device generations from a same vendor.

In some implementations, the process of replacing the source system **112** with the destination system **122** (also referred to herein as a "migration process") may include copying the data stored on the source system **112** to the destination system **122**. Further, after completing the migration process, the destination storage device **120** may receive input data from the client device **105**, and may persistently store the received data. Further, the data stored on the destination storage device **120** may be replicated to the destination replication device **125**.

In some implementations, some or all of the devices **110**, **115**, **120**, **125** may be implemented using persistent (e.g., nonvolatile) storage device(s), such as disk-based storage device(s) (e.g., hard disk drive(s) (HDDs)), solid state device(s) (SSDs) such as flash storage device(s), and the like. For example, the devices **110**, **115**, **120**, **125** may be different storage arrays that each include multiple storage components (e.g., HDDs, SSDs, etc.).

In some implementations, the destination storage device **120** may include a controller **130** to manage storage operations. The controller **130** may be implemented via hardware (e.g., electronic circuitry) or a combination of hardware and programming (e.g., comprising at least one processor and instructions executable by the at least one processor and stored on at least one machine-readable storage medium).

In some implementations, the controller **130** may include functionality to manage a migration process to replace the source system **112** with the destination system **122**. The controller **130** may initiate the migration process in response to the receipt of a command or message (e.g., a request from a human user to perform the migration process). In some implementations, the migration process may include defining a consistency group that includes all replicated volumes on the source storage device **110** (i.e., the volumes that are replicated to the source replication device **115**), and also includes a dummy control volume that has no data content. The migration process may also include transferring the replicated volumes from the source storage device **110** to the destination storage device **120**, and then initiating a data replication from the destination storage device **120** to the destination replication device **125**. Further, after completing the data replication, the migration process may include transferring the control volume from the source storage device **110** to the destination storage device **120**, thereby completing the migration of the consistency group. In this manner, the migration process may be completed while maintaining data storage and replication. An example migration process is described in greater detail below with reference to FIGS. **2**-**3**F.

FIGS. **2**-**3**F—Example Migration Process

FIG. **2** shows an example migration process **200**, in accordance with some implementations. The process **200** may be implemented in hardware or a combination of hardware and programming (e.g., machine-readable instructions executable by a processor(s)). The machine-readable instructions may be stored in a non-transitory computer readable medium, such as an optical, semiconductor, or magnetic storage device. The machine-readable instructions may be executed by a single processor, multiple processors, a single processing engine, multiple processing engines, and so forth. For the sake of illustration, details of the process **200** may be described below with reference to FIGS. **1** and **3**A-**3**F, which show example implementations. However, other implementations are also possible.

Block **210** may include receiving a request to initiate a migration from a source storage system to a destination storage system. Block **220** may include establishing a migration link between the source storage device and the destination storage device. Block **230** may include establishing a replication link between the destination storage device and a destination replication device. For example, referring to FIG. **3**A, the source storage device **110** receives data inputs/outputs (I/Os) from the client device **105** via a data link **316**. Further, the source storage device **110** stores data in replicated volumes **310** that are automatically copied to the source replication device **115**. Subsequently, the controller **130** receives a request (e.g., a user command, program instruction, etc.) to initiate a migration from the source system **112** to the destination system **122**. In response to the request, the controller **130** establishes a migration link **312** between the source storage device **110** and the destination storage device **120**. Further, the controller **130** establishes a replication link **314** between the destination storage device **120** and the destination replication device **125**.

Referring again to FIG. **2**, block **240** may include creating, on the destination storage device, a set of proxy volumes associated with a set of replicated volumes on the source storage device. For example, referring to FIG. **3**B, the controller initiates or registers the proxy volumes **330** on the destination storage device **120** (also referred to as "admitting" the proxy volumes **330** on destination storage device **120**). Each proxy volume **330** represents (or is otherwise associated with) a different replicated volume **310** on the source storage device **110**. When each proxy volume **330** is registered or admitted on the destination storage device **120**, that proxy volume **330** is viewed by the client device **105** as representing a corresponding replicated volume **310**.

Referring again to FIG. **2**, block **250** may include establish a data link between a client device and the destination storage device. For example, referring to FIG. **3**B, the controller establishes a data link **322** between the client device **105** and the destination storage device **120**. Further, the client device **105** sends data I/Os to the proxy volumes **330** via the data link **322**, and the proxy volumes **330** forward these data I/Os (represented by dotted arrow **326**) to the corresponding replicated volumes **310** (e.g., via the migration link **312**).

Referring again to FIG. **2**, block **260** may include creating a control volume on the source storage device. For example, referring to FIG. **3**B, the controller creates the control volume **320** on the source storage device **110**. In some implementations, the control volume **320** is a dummy volume that does not include any data, and is used to control the progression of the migration from the source system **112** to the destination system **122**.

Referring again to FIG. **2**, block **270** may include creating a consistency group including the replicated volumes and the control volume of the source storage device. For example, referring to FIG. **3**C, the controller creates the consistency group **340** that includes the replicated volumes **310** and the control volume **320** (on source storage device **110**). As used herein, the term "consistency group" refers to a specified set of data elements (e.g., volumes, files, etc.) that are migrated together (e.g., during a single migration operation). In some implementations, creating the consistency group **340** initiates or defines a grouped migration that is not completed until all data elements in the consistency group **340** (i.e., both the replicated volumes **310** and the control volume **320**) are fully migrated to the destination storage device **120**. Further, the controller removes the data link **316** between client device **105** and source storage device **110**.

Referring again to FIG. **2**, block **280** may include initiating, based on the consistency group, a data copy from the replicated volumes of the source storage device to the proxy volumes of the destination storage device. For example, referring to FIG. **3**C, the controller initiates a data copy **342** (e.g., via the migration link **312**) from the replicated volumes **310** to the proxy volumes **330**. The data copy **342** may be performed based on (or in accordance with) the consistency group **340**. For example, in some implementations, the data copy **342** transfers a copy of a first portion (i.e., the replicated volumes **310**) of the consistency group **340** into the destination storage device **120**, but does not transfer a copy of a second portion (i.e., the control volume **320**) of the consistency group **340** into the destination storage device **120**. As such, the consistency group **340** is not fully migrated upon completing the data copy **342** (i.e., by only copying the data of the replicated volumes **310** to the destination storage device **120**).

In some implementations, while the data copy **342** is being performed, the storage systems **112**, **122** may continue to perform migration operations. For example, the proxy volumes **330** may continue to forward the data I/Os to the replicated volumes **310** on the source storage device **110**, and the replicated volumes **310** on the source storage device **110** may continue to be replicated to the replicated storage device **115**.

Referring again to FIG. **2**, block **290** may include, upon completion of the data copy, initiate a replication of the proxy volumes from the destination storage device to a destination replication device. For example, referring to FIG. **3**D, the controller determines that the data copy **342** has been completed, and in response initiates a data replication **344** (e.g., via the replication link **314**) of the proxy volumes **330** from the destination storage device **120** to the destination replication device **125**. The data replication **344** may generate the replicated volumes **310** on the destination replication device **125**.

In some implementations, while the data replication **344** is being performed, the storage systems **112**, **122** may continue to perform migration operations. For example, the proxy volumes **330** may continue to forward the data I/Os to the replicated volumes **310** on the source storage device **110**, and the replicated volumes **310** on the source storage device **110** may continue to be replicated to the replicated storage device **115**.

Referring again to FIG. **2**, block **295** may include, upon completion of the replication of the proxy volumes, copy the control volume from the source storage device to the destination storage device. After block **295**, the process **200** may be completed. For example, referring to FIG. **3**E, the controller **130** determines that the data replication **344** has been completed, and in response perform a data copy **352** (e.g., via the migration link **314**) to copy the control volume **320** from the source storage device **110** into the destination storage device **120**.

In some implementations, copying the control volume **320** into the destination storage device **120** completes the migration of the consistency group **340** (including the replicated volumes **310** and the control volume **320**). Further, upon completing the migration of the consistency group **340**, one or more actions may be performed to complete the switch-over from the source system **112** to the destination system **122**. For example, referring to FIG. **3**F, the controller **130** deletes the consistency group **340**, deletes the copies of the control volume **320** (in the source storage device **110** and the destination storage device **120**), and also removes the migration link **312**. Further, the controller **130** converts the proxy volumes **330** into replicated volumes **310** on the destination storage device **120**. After converting the proxy volumes **330** into the replicated volumes **310** on the destination storage device **120**, these replicated volumes **310** no longer forward the data I/Os to the replicated volumes **310** on the source storage device **110**. Rather, the data I/Os are only applied to the replicated volumes **310** on the destination storage device **120**, and are replicated on the destination replication device **125**. Subsequently, the storage system **112** is no longer updated with new data and may thus store stale data **360** (e.g., an older copy of the replicated volumes **310**), or may be taken offline.

FIG. **4**—Example Management System

FIG. **4** shows a schematic diagram of an example management system **400**. In some examples, the management system **400** may correspond generally to some or all of the controller **130** (shown in FIG. **1**). As shown, the management system **400** may include a controller **402** and machine-readable storage **405** including instructions **410**-**450**. The machine-readable storage **405** may be a non-transitory medium. The instructions **410**-**450** may be executed by the controller **402**, or by a processing engine included in the controller **402**.

Instruction **410** may be executed to establish a migration link between a first storage device and a second storage device, where the first storage device stores a set of replicating volumes that are replicated on a first replication device. For example, referring to FIG. **3**A, the source storage device **110** receives data inputs/outputs (I/Os) from the client device **105**, and stores data in replicated volumes **310** that are automatically copied to the source replication device **115**. The controller **130** receives a request to initiate a migration, and in response establishes a migration link **312** between the source storage device **110** and the destination storage device **120**. In some implementations, the controller **130** establishes a replication link **314** between the destination storage device **120** and the destination replication device **125**, and admits the proxy volumes **330** on the destination storage device **120**. Further, referring to FIG. **3**B, the controller **130** admits the proxy volumes **330** on the

destination storage device **120**, establishes a data link **322** between the client device **105** and the destination storage device **120**, and creates the control volume **320** on the source storage device **110**.

Instruction **420** may be executed to create a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, where the consistency group is a set of data elements that are migrated together. For example, referring to FIG. **3**C, the controller creates the consistency group **340** that includes the replicated volumes **310** and the control volume **320** stored on source storage device **110**). Further, the controller removes the data link **316** between client device **105** and source storage device **110**.

Instruction **430** may be executed to initiate, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, where the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes. For example, referring to FIG. **3**B, the client device **105** sends data I/Os to the proxy volumes **330** via the data link **322**. The proxy volumes **330** forward the received data I/Os (represented by dotted arrow **326**) to the corresponding replicated volumes **310** (e.g., via the migration link **312**). Further, referring to FIG. **3**C, the controller initiates a data copy **342** (e.g., via the migration link **312**) from the replicated volumes **310** to the proxy volumes **330**. The data copy **342** is performed based on the consistency group **340**.

Instruction **440** may be executed to, in response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiate a replication of the set of proxy volumes from the second storage device to a second replication device. For example, referring to FIG. **3**D, the controller determines that the data copy **342** has been completed, and in response initiates a data replication **344** (e.g., via the replication link **314**) of the proxy volumes **330** from the destination storage device **120** to the destination replication device **125**. The data replication **344** stores the replicated volumes **310** on the destination replication device **125**.

Instruction **450** may be executed to, in response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transfer a copy of the control volume from the first storage device into the second storage device, where transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device. For example, referring to FIG. **3**E, the controller determines that the data replication **344** has been completed, and in response perform a data copy **352** (e.g., via the migration link **314**) to copy the control volume **320** from the source storage device **110** into the destination storage device **120**. In some implementations, copying the control volume **320** into the destination storage device **120** completes the migration of the consistency group **340** (including the replicated volumes **310** and the control volume **320**).

In some implementations, after (or as part of) a completion of the migration of the consistency group **340**, one or more actions may be performed to complete the switch-over from the source system **112** to the destination system **122**. For example, referring to FIG. **3**F, the controller deletes the consistency group **340**, deletes the copies of the control volume **320** (in the source storage device **110** and the destination storage device **120**), and also removes the migration link **312**. Further, the controller **130** converts the proxy volumes **330** into replicated volumes **310** on the destination storage device **120**.

FIG. **5**—Example Process

FIG. **5** shows an example process **500**, in accordance with some implementations. In some examples, the process **500** may be performed by a processor or controller (e.g., the controller **130** shown in FIG. **1**). The process **500** may be implemented in hardware or a combination of hardware and programming (e.g., machine-readable instructions executable by a processor(s)). The machine-readable instructions may be stored in a non-transitory computer readable medium, such as an optical, semiconductor, or magnetic storage device. The machine-readable instructions may be executed by a single processor, multiple processors, a single processing engine, multiple processing engines, and so forth. However, other implementations are also possible.

Block **510** may include establishing, by a controller, a migration link between a first storage device and a second storage device, where the first storage device stores a set of replicating volumes that are replicated on a first replication device. Block **520** may include creating, by the controller, a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, where the consistency group is a set of data elements that are migrated together.

Block **530** may include the controller initiating, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, where the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes. Block **540** may include, in response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiating, by the controller, a replication of the set of proxy volumes from the second storage device to a second replication device.

Block **550** may include, in response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transferring, by the controller, a copy of the control volume from the first storage device into the second storage device, where transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device. Blocks **510**-**550** may correspond generally to the examples described above with reference to instructions **410**-**450** (shown in FIG. **4**).

FIG. **6**—Example Machine-Readable Medium

FIG. **6** shows a machine-readable medium **600** storing instructions **610**-**650**, in accordance with some implementations. The instructions **610**-**650** can be executed by a controller (e.g., controller **130** shown in FIG. **1**), such as a single processor, multiple processors, a single processing engine, multiple processing engines, and so forth. The machine-readable medium **600** may be a non-transitory storage medium, such as an optical, semiconductor, or magnetic storage medium. The instructions **610**-**650** may correspond generally to the examples described above with reference to instructions **410**-**450** (shown in FIG. **4**).

Instruction **610** may be executed to establish a migration link between a first storage device and a second storage device, where the first storage device stores a set of replicating volumes that are replicated on a first replication

device. Instruction **620** may be executed to create a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, where the consistency group is a set of data elements that are migrated together. Instruction **630** may be executed to initiate, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, where the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes.

Instruction **640** may be executed to, in response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiate a replication of the set of proxy volumes from the second storage device to a second replication device. Instruction **650** may be executed to, in response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transfer a copy of the control volume from the first storage device into the second storage device, where transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device.

CONCLUSION

In accordance with some implementations described herein, a controller may perform a migration process to replace a source storage system with destination storage system. The source storage system and the destination storage system may each include a primary storage device and a secondary replication device. In some implementations, the migration process may include defining a consistency group that includes all replicated volumes on the source storage device, and also includes a dummy control volume that has no data content. The migration process may also include transferring the replicated volumes from the source storage device to the destination storage device, and initiating a data replication from the destination storage device to the destination replication device. Further, after completing the data replication, the migration process may include transferring the control volume from the source storage device to the destination storage device, thereby completing the migration of the consistency group. In this manner, the migration process may be completed while maintaining data storage and replication.

Note that, while FIGS. **1-6** show various examples, implementations are not limited in this regard. For example, referring to FIG. **1**, it is contemplated that the system **100** may include additional devices and/or components, fewer components, different components, different arrangements, and so forth. In another example, it is contemplated that each of the devices **110**, **115**, **125** may also include controllers to manage the operation of the respective device **110**, **115**, **125**. In yet another example, it is contemplated that the functionality of the system **100** described above may be included in any another engine or software. Other combinations and/or variations are also possible.

Data and instructions are stored in respective storage devices, which are implemented as one or multiple computer-readable or machine-readable storage media. The storage media include different forms of non-transitory memory including semiconductor memory devices such as dynamic or static random access memories (DRAMs or SRAMs), erasable and programmable read-only memories (EPROMs), electrically erasable and programmable read-only memories (EEPROMs) and flash memories; magnetic disks such as fixed, floppy and removable disks; other magnetic media including tape; optical media such as compact disks (CDs) or digital video disks (DVDs); or other types of storage devices.

Note that the instructions discussed above can be provided on one computer-readable or machine-readable storage medium, or alternatively, can be provided on multiple computer-readable or machine-readable storage media distributed in a large system having possibly plural nodes. Such computer-readable or machine-readable storage medium or media is (are) considered to be part of an article (or article of manufacture). An article or article of manufacture can refer to any manufactured single component or multiple components. The storage medium or media can be located either in the machine running the machine-readable instructions, or located at a remote site from which machine-readable instructions can be downloaded over a network for execution.

In the foregoing description, numerous details are set forth to provide an understanding of the subject disclosed herein. However, implementations may be practiced without some of these details. Other implementations may include modifications and variations from the details discussed above. It is intended that the appended claims cover such modifications and variations.

In the present disclosure, use of the term "a," "an," or "the" is intended to include the plural forms as well, unless the context clearly indicates otherwise. Also, the term "includes," "including" "comprises," "comprising" "have," or "having" when used in this disclosure specifies the presence of the stated elements, but do not preclude the presence or addition of other elements.

What is claimed is:

1. A management system comprising:

a controller; and

a machine-readable storage storing instructions, the instructions executable by the processor to:

establish a migration link between a first storage device and a second storage device, wherein the first storage device stores a set of replicating volumes that are replicated on a first replication device;

create a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, wherein the consistency group is a set of data elements that are migrated together;

initiate, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, wherein the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes;

in response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiate a replication of the set of proxy volumes from the second storage device to a second replication device; and

in response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transfer a copy of the control volume from the first storage device into the second storage device, wherein transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device.

2. The management system of claim **1**, including instructions executable by the controller to:

create the control volume as an empty volume included in the first storage device.

3. The management system of claim 1, including instructions executable by the controller to:

after completing the migration of the consistency group, convert the set of proxy volumes into a second set of replicating volumes that are replicated on the second replication device.

4. The management system of claim 1, including instructions executable by the controller to:

after completing the migration of the consistency group:

delete the consistency group;

delete the control volume stored on the first storage device; and

delete the control volume stored on the second storage device.

5. The management system of claim 1, including instructions executable by the controller to:

perform the data copy using the migration link between the first storage device and the second storage device; and

after completing the migration of the consistency group, remove the migration link between the first storage device and the second storage device.

6. The management system of claim 1, including instructions executable by the controller to:

establish a first data link between a client device and the second storage device;

receive, from the client device, the I/O transactions via the first data link; and

remove a second data link between the client device and the first storage device.

7. The management system of claim 1, wherein the control volume is not replicated on the first replication device.

8. The management system of claim 1, wherein the first storage device and the first replication device use a first storage technology, and wherein the second storage device and the second replication device use a second storage technology that is different from the first storage technology.

9. The management system of claim 1, wherein the controller is included in one of the second storage device and a system management device.

10. The method of claim 1, wherein the controller is included in one of the second storage device and a system management device.

11. A method comprising:

establishing, by a controller, a migration link between a first storage device and a second storage device, wherein the first storage device stores a set of replicating volumes that are replicated on a first replication device;

creating, by the controller, a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, wherein the consistency group is a set of data elements that are migrated together;

the controller initiating, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, wherein the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes;

in response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiating, by the controller, a replication of the set of proxy volumes from the second storage device to a second replication device; and

in response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transferring, by the controller, a copy of the control volume from the first storage device into the second storage device, wherein transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device.

12. The method of claim 11, comprising:

establishing a first data link between a client device and the second storage device;

receiving, from the client device, the I/O transactions via the first data link;

creating the control volume as an empty volume included in the first storage device; and

removing a second data link between the client device and the first storage device.

13. The method of claim 11, comprising, after completing the migration of the consistency group:

removing the migration link between the first storage device and the second storage device; and

converting the set of proxy volumes into a second set of replicating volumes that are replicated on the second replication device.

14. The method of claim 11, wherein the first storage device and the first replication device use a first storage technology, and wherein the second storage device and the second replication device use a second storage technology that is different from the first storage technology.

15. The method of claim 13, comprising, after completing the migration of the consistency group:

deleting the consistency group;

deleting the control volume stored on the first storage device; and

deleting the control volume stored on the second storage device.

16. A non-transitory machine-readable medium storing instructions that upon execution cause a controller to:

establish a migration link between a first storage device and a second storage device, wherein the first storage device stores a set of replicating volumes that are replicated on a first replication device;

create a consistency group comprising the set of replicating volumes and a control volume stored on the first storage device, wherein the consistency group is a set of data elements that are migrated together;

initiate, based on the consistency group, a data copy from the set of replicating volumes to a set of proxy volumes on the second storage device, wherein the proxy volumes forward input/output (I/O) transactions to the set of replicating volumes;

in response to a completion of the data copy from the set of replicating volumes to the set of proxy volumes, initiate a replication of the set of proxy volumes from the second storage device to a second replication device; and

in response to a completion of the replication of the set of proxy volumes from the second storage device to the second replication device, transfer a copy of the control volume from the first storage device into the second storage device, wherein transferring the copy of the control volume into the second storage device completes a migration of the consistency group from the first storage device to the second storage device.

17. The non-transitory machine-readable medium of claim 16, including instructions that upon execution cause the controller to:

establish a first data link between a client device and the second storage device;

receive, from the client device, the I/O transactions via the first data link;

create the control volume as an empty volume included in the first storage device; and

remove a second data link between the client device and the first storage device.

18. The non-transitory machine-readable medium of claim **16**, including instructions that upon execution cause the controller to:

after completing the migration of the consistency group:

remove the migration link between the first storage device and the second storage device; and

convert the set of proxy volumes into a second set of replicating volumes that are replicated on the second replication device.

19. The non-transitory machine-readable medium of claim **16**, including instructions that upon execution cause the controller to:

after completing the migration of the consistency group:

delete the consistency group;

delete the control volume stored on the first storage device; and

delete the control volume stored on the second storage device.

20. The non-transitory machine-readable medium of claim **16**, wherein the first storage device and the first replication device use a first storage technology, and wherein the second storage device and the second replication device use a second storage technology that is different from the first storage technology.

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