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(54) **ISOLATING HARDWARE AND NETWORK FAILURES IN A COMPUTING ENVIRONMENT**

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G06F 11/00 (2006.01)
G06F 11/07 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 11/079*** (2013.01); ***G06F 11/0709*** (2013.01); ***G06F 11/0751*** (2013.01)

(58) **Field of Classification Search**
CPC . G06F 11/0709; G06F 11/0751; G06F 11/079
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,460,070	B1 *	10/2002	Turek	G06F 11/0709 709/202
8,031,634	B1 *	10/2011	Artzi	H04L 12/4641 370/254
8,381,033	B2 *	2/2013	Franklin	G06F 11/0712 714/25
8,856,589	B1	10/2014	Glade et al.	
8,990,629	B2 *	3/2015	Salame	G06F 11/079 714/26
8,996,932	B2 *	3/2015	Singh	G06F 11/2294 714/47.3
9,495,234	B1 *	11/2016	Hamman	G06F 11/079
2003/0041095	A1	2/2003	Konda et al.	
2008/0244532	A1	10/2008	Arcese et al.	
2014/0351648	A1	11/2014	Madani et al.	
2015/0089331	A1	3/2015	Skerry et al.	
2016/0170848	A1 *	6/2016	Yang	G06F 11/2023 714/4.12

FOREIGN PATENT DOCUMENTS

EP	2216732	A1	9/2010
WO	2014063110	A1	4/2014
WO	2014162291	A1	9/2014

* cited by examiner

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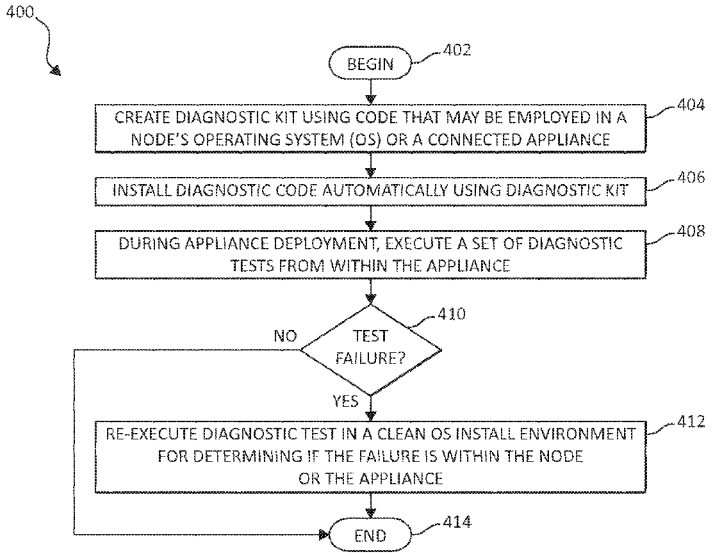
(57) **ABSTRACT**

Various embodiments for method for detecting network and hardware failures in a computing environment, by a processor device, are provided. In one embodiment, a method comprises isolating component failures by deploying a diagnostic code within an Operating System (OS) of both a first node and a connected appliance, and executing a set of diagnostic tests using the diagnostic code to determine if the source of the failure is within the first node or the connected appliance.

18 Claims, 3 Drawing Sheets



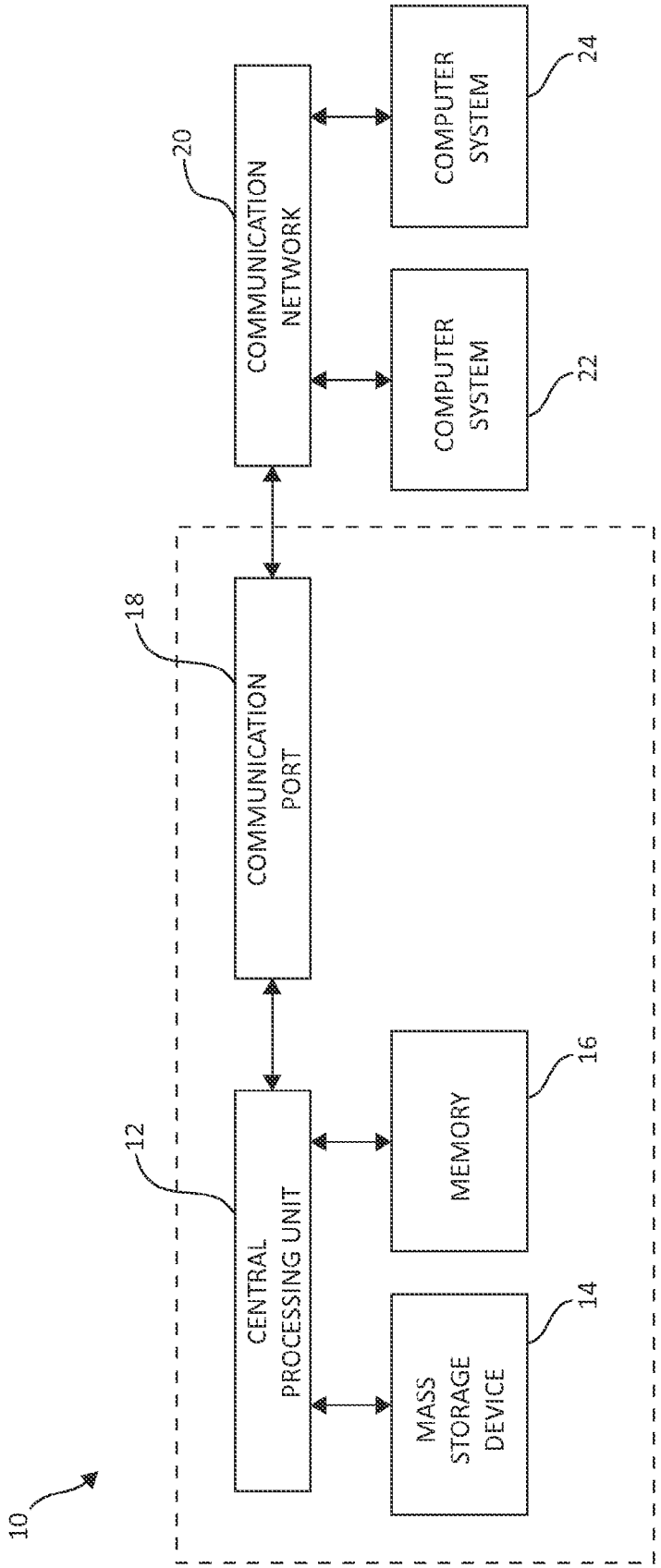

10
12
CENTRAL PROCESSING UNIT
14
MASS STORAGE DEVICE
16
MEMORY
18
COMMUNICATION PORT
20
COMMUNICATION NETWORK
22
COMPUTER SYSTEM
24
COMPUTER SYSTEM

FIG. 1

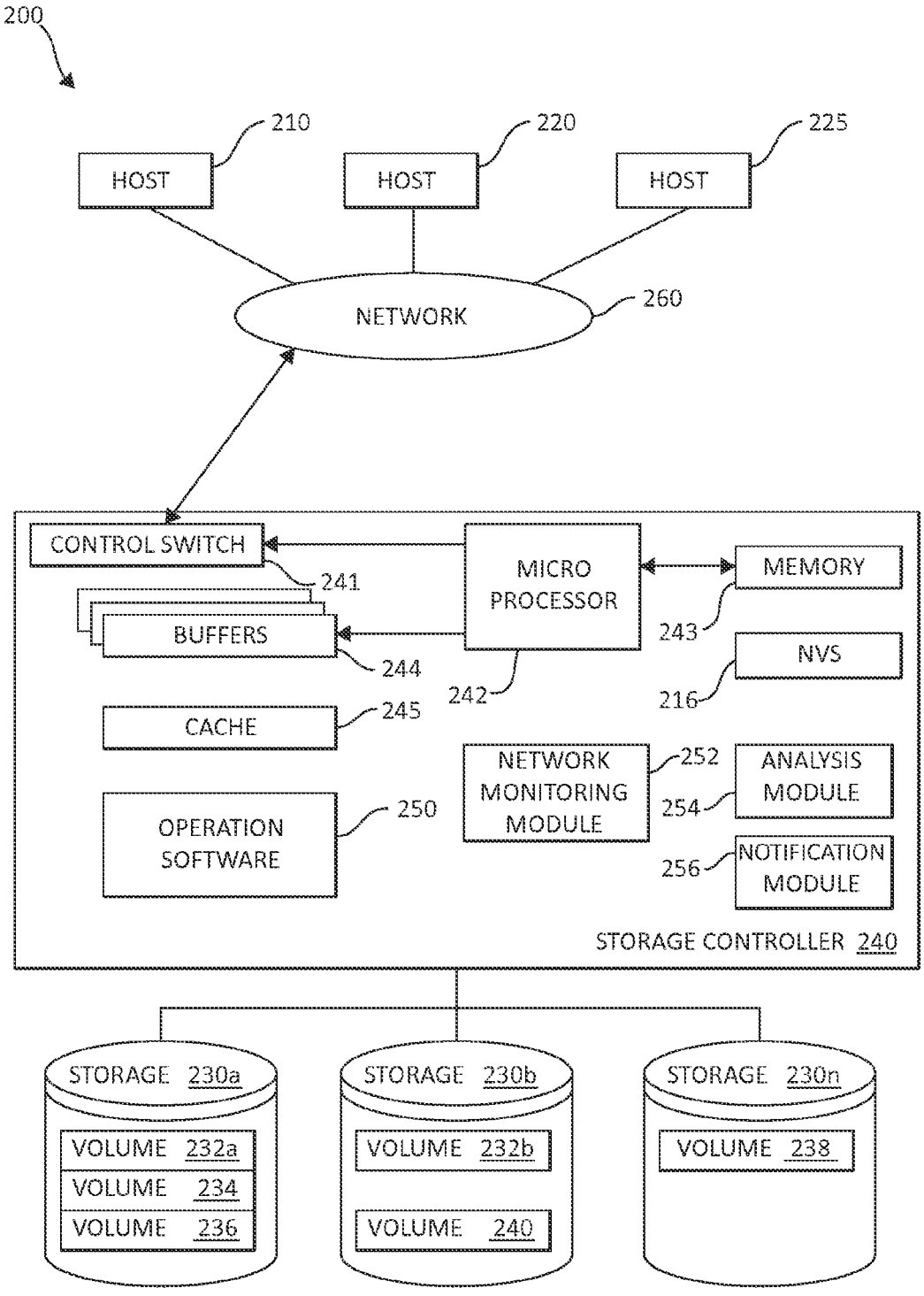

200
HOST
210
HOST
220
HOST
225
NETWORK
260
CONTROL SWITCH
241
BUFFERS
244
CACHE
245
OPERATION SOFTWARE
250
MICRO PROCESSOR
242
MEMORY
243
NVS
216
NETWORK MONITORING MODULE
252
ANALYSIS MODULE
254
NOTIFICATION MODULE
256
STORAGE CONTROLLER 240
STORAGE 230a
VOLUME 232a
VOLUME 234
VOLUME 236
STORAGE 230b
VOLUME 232b
VOLUME 240
STORAGE 230n
VOLUME 238

FIG. 2

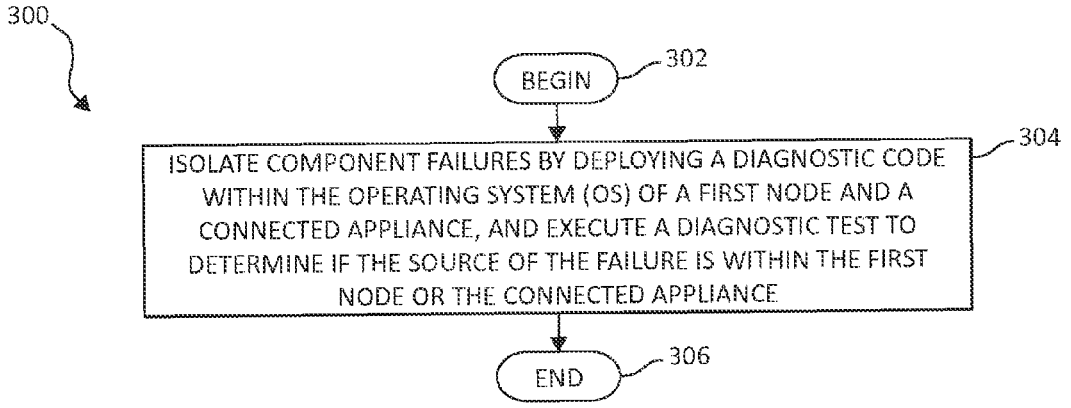

300
BEGIN
302
ISOLATE COMPONENT FAILURES BY DEPLOYING A DIAGNOSTIC CODE WITHIN THE OPERATING SYSTEM (OS) OF A FIRST NODE AND A CONNECTED APPLIANCE, AND EXECUTE A DIAGNOSTIC TEST TO DETERMINE IF THE SOURCE OF THE FAILURE IS WITHIN THE FIRST NODE OR THE CONNECTED APPLIANCE
304
END
306

FIG. 3

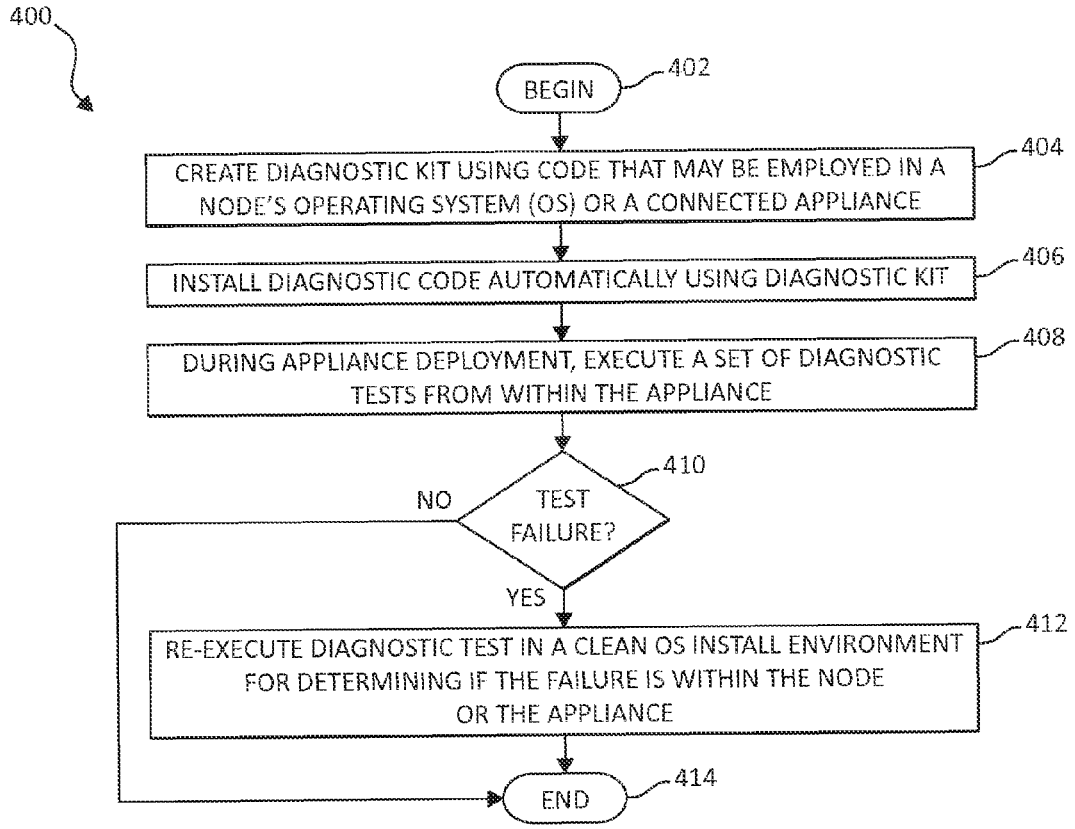

400
BEGIN
402
CREATE DIAGNOSTIC KIT USING CODE THAT MAY BE EMPLOYED IN A NODE'S OPERATING SYSTEM (OS) OR A CONNECTED APPLIANCE
404
INSTALL DIAGNOSTIC CODE AUTOMATICALLY USING DIAGNOSTIC KIT
406
DURING APPLIANCE DEPLOYMENT, EXECUTE A SET OF DIAGNOSTIC TESTS FROM WITHIN THE APPLIANCE
408
TEST FAILURE?
410
NO
YES
RE-EXECUTE DIAGNOSTIC TEST IN A CLEAN OS INSTALL ENVIRONMENT FOR DETERMINING IF THE FAILURE IS WITHIN THE NODE OR THE APPLIANCE
412
END
414

FIG. 4

ISOLATING HARDWARE AND NETWORK FAILURES IN A COMPUTING ENVIRONMENT

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates in general to computing systems, and more particularly, to various embodiments for detecting network and hardware failures in a computing environment.

Description of the Related Art

Today with modern technology, large volumes of data are storable on disk drives; these drives can exist as a solo entity, or as part of a broader make up within a larger storage environment, for example, as part of a Storage Area Network (SAN), or Software Defined Storage (SDS) systems, such as a Virtual Storage Area Network (VSAN). Typically, these storage environments comprise of appliances, or virtual appliances in SDS, built to store, transfer, and handle data. As the sheer volume of data in today's information-based society continues to increase, so too does the demands placed on communications and data processing infrastructures that serve to manipulate, transfer, and otherwise handle this data.

SUMMARY OF THE INVENTION

Various embodiments for detecting network and hardware failures in a computing environment, by a processor device, are provided. In one embodiment, a method comprises isolating component failures by deploying a diagnostic code within an Operating System (OS) of both a first node and a connected appliance, and executing a set of diagnostic tests using the diagnostic code to determine if the source of the failure is within the first node or the connected appliance.

In addition to the foregoing exemplary embodiment, various other system and computer program product embodiments are provided and supply related advantages. The foregoing summary has been provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter. The claimed subject matter is not limited to implementations that solve any or all disadvantages noted in the background.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the advantages of the invention will be readily understood, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments that are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings, in which:

FIG. **1** illustrates a block diagram showing an exemplary hardware structure for effecting data routing management, in which aspects of the present invention may be realized;

FIG. **2** illustrates an additional block diagram of an exemplary hardware structure, specifically portions of a complex SAN, again, in which aspects of the present invention may be realized;

FIG. **3** illustrates a flow chart of a method for detecting network and hardware failures in a computing environment; and

FIG. **4** illustrates an additional flow chart of a method for detecting network and hardware failures in a computing environment.

DETAILED DESCRIPTION OF THE DRAWINGS

Described embodiments, and illustrative Figures of a method for data routing management are to follow. In the interest of clarity, not all features of an actual implementation are described in this Specification. It will of course be appreciated by the skilled artisan, that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Furthermore, it will be appreciated that such a development effort may be complex and labor-intensive, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this Disclosure.

Complex Storage Area Network (SAN) or Virtual Storage Area Network (VSAN) configurations enable large numbers of computing components, appliances, or virtual (software-defined) appliances, such as servers to access common storage via interconnection switches and cabling. The availability, integrity and recovery of these interconnections is critical to the reliable operations of the systems. Networks are often implemented with redundant routes, in conjunction with server multipath drivers allowing for failing commands to be recovered down alternate paths and avoiding outages and individual path failures.

A significant challenge with software-defined appliances is the shared responsibility of reliability between the software vendor and the hardware of an end user. The software vendor is accountable and responsible for the appliance software, and the end user is accountable and responsible for the hardware and its ecosystem. Accordingly, when errors or failures arise, determining the source side of the issue, whether within the software of the vendor or within the hardware of the end user, proves to be a challenging and indiscernible task.

Traditionally, to determine the source of a failure, appliance software diagnoses the hardware and network, and indicates the found errors. This method, however, is not sufficient, particularly in software-defined environments comprising virtual appliances. Because appliance software provides a diagnosis indicating found errors, and those diagnoses are based upon a solution executed within a code-complex virtual appliance, it is often indiscernible whether the errors are occurring within the software of the virtual appliance, or the Operating Software (OS) of the hardware system itself. The distinction is important, since a user, or "customer", is responsible for maintaining hardware including its OS, and a "vendor" is responsible for maintaining the appliance or virtual appliance. Consider the following example, in which there determines to be a communication loss between two nodes. The communication loss may originate due to an error within the virtual appliance (i.e. network settings/firewall rules), or the loss may originate due to firewall rules within a switch or other communication equipment in the user's environment.

In view of the foregoing, the mechanisms of the illustrated embodiments provide various solutions to the previous challenges for isolating hardware and network failures in a

computing environment. These mechanisms include such functionality as creating a platform-agnostic diagnostic kit to diagnose and pinpoint the source of found errors and failures, as will be further described.

The mechanisms may be applicable to a variety of network topologies and network components as will be further described. Notwithstanding the illustration of some of the functionality attendant to the various embodiments, one of ordinary skill will appreciate that the methodologies herein may be adapted to a wide variety of implementations and scenarios as noted above.

Turning now to FIG. **1**, exemplary architecture **10** of a computing system environment is depicted. Architecture **10** may, in one embodiment, be implemented at least as part of a system for effecting mechanisms of the present invention. The computer system **10** includes central processing unit (CPU) **12**, which is connected to communication port **18** and memory device **16**. The communication port **18** is in communication with a communication network **20**. The communication network **20** and storage network may be configured to be in communication with server (hosts) **22**, **24** and storage systems, which may include storage devices **14**. The storage systems may include hard disk drive (HDD) devices, solid-state devices (SSD) etc., which may be configured in a redundant array of independent disks (RAID). The communication port **18**, communication network **20**, and other components not pictured for the sake of brevity but known to the skilled artisan may include such hardware components as fibre channel cabling, fibre channel ports, Host-Bus Adapters (HBAs), Converged Network Adapters (CNAs), network switches and switching components, and similar communications mechanisms known to one of ordinary skill in the art. Various aspects of the illustrated embodiments may be realized using one or more of these components as will be further described.

The operations as described below may be executed on storage device(s) **14**, located in system **10** or elsewhere and may have multiple memory devices **16** working independently and/or in conjunction with other CPU devices **12**. Memory device **16** may include such memory as electrically erasable programmable read only memory (EEPROM) or a host of related devices. Memory device **16** and storage devices **14** are connected to CPU **12** via a signal-bearing medium. In addition, CPU **12** is connected through communication port **18** to a communication network **20**, having an attached plurality of additional computer host systems **22**, **24**. In addition, memory device **16** and the CPU **12** may be embedded and included in each component of the computing system **10**. Each storage system may also include separate and/or distinct memory devices **16** and CPU **12** that work in conjunction or as a separate memory device **16** and/or CPU **12**.

FIG. **2** is an exemplary block diagram **200** showing a hardware structure of a data storage and management system (specifically, portions of a SAN **200**) that may be used in the overall context of isolating hardware and network failures in accordance with the present invention. Host computers **210**, **220**, **225**, are shown, each acting as a central processing unit for performing data processing as part of a data storage system **200**. The cluster hosts/nodes (physical or virtual devices), **210**, **220**, and **225** may be one or more new physical devices or logical devices to accomplish the purposes of the present invention in the data storage system **200**.

A Network connection **260** may be a fibre channel fabric, a fibre channel point to point link, a fibre channel over ethernet fabric or point to point link, a FICON or ESCON I/O interface, any other I/O interface type, a wireless network, a wired network, a LAN, a WAN, heterogeneous, homogeneous, public (i.e. the Internet), private, or any combination thereof. The hosts, **210**, **220**, and **225** may be local or distributed among one or more locations and may be equipped with any type of fabric (or fabric channel) (not shown in FIG. **2**) or network adapter **260** to the storage controller **240**, such as Fibre channel, FICON, ESCON, Ethernet, fiber optic, wireless, or coaxial adapters. Data storage system **200** is accordingly equipped with a suitable fabric (not shown in FIG. **2**) or network adaptor **260** to communicate. Data storage system **200** is depicted in FIG. **2** comprising storage controllers **240** and cluster hosts **210**, **220**, and **225**. The cluster hosts **210**, **220**, and **225** may include cluster nodes and other network components known to one of ordinary skill in the art.

To facilitate a clearer understanding of the methods described herein, storage controller **240** is shown in FIG. **2** as a single processing unit, including a microprocessor **242**, system memory **243** and nonvolatile storage ("NVS") **216**. It is noted that in some embodiments, storage controller **240** is comprised of multiple processing units, each with their own processor complex and system memory, and interconnected by a dedicated network within data storage system **200**. Storage **230** (labeled as **230***a*, **230***b*, and **230***n* herein) may be comprised of one or more storage devices, such as storage arrays, which are connected to storage controller **240** (by a storage network) with one or more cluster hosts **210**, **220**, and **225** connected to each storage controller **240** through network **260**. While one data connection between components (such as between storage **230** and storage controller **240**, and network connection **260** and cluster hosts **210**, **220**, and **225**) is shown for purposes of brevity, one of ordinary skill in the art will appreciate that a number of network connections, or "paths" may be found in a particular system or scenario in which data is transferred. These paths form the multipath architecture of storage networks in which the mechanisms of the present invention are concerned, among other aspects. In addition, alternate network paths appreciated by one of ordinary skill in the art may be found.

Storage controller **240** manages storage **230** and facilitates the processing of write and read requests intended for storage **230**. The system memory **243** of storage controller **240** stores program instructions and data, which the processor **242** may access for executing functions and method steps of the present invention for executing and managing storage **230** as described herein. In one embodiment, system memory **243** includes, is in association with, or is in communication with the operation software **250** for performing methods and operations described herein. As shown in FIG. **2**, system memory **243** may also include or be in communication with a cache **245** for storage **230**, also referred to herein as a "cache memory", for buffering "write data" and "read data", which respectively refer to write/read requests and their associated data. In one embodiment, cache **245** is allocated in a device external to system memory **243**, yet remains accessible by microprocessor **242** and may serve to provide additional security against data loss, in addition to carrying out the operations as described in herein.

In some embodiments, cache **245** is implemented with a volatile memory and non-volatile memory and coupled to microprocessor **242** via a local bus (not shown in FIG. **2**) for enhanced performance of data storage system **200**. The NVS **216** included in data storage controller is accessible by microprocessor **242** and serves to provide additional support for operations and execution of the present invention as

described in other figures. The NVS **216**, may also referred to as a "persistent" cache, or "cache memory" and is implemented with nonvolatile memory that may or may not utilize external power to retain data stored therein. The NVS may be stored in and with the cache **245** for any purposes suited to accomplish the objectives of the present invention. In some embodiments, a backup power source (not shown in FIG. **2**), such as a battery, supplies NVS **216** with sufficient power to retain the data stored therein in case of power loss to data storage system **200**. In certain embodiments, the capacity of NVS **216** is less than or equal to the total capacity of cache **245**.

Storage **230** may be physically comprised of one or more storage devices, such as a hard disk, magnetic tape, solid-state flash memory, or other non-volatile memory or any combination thereof. Additionally, Storage **230** may be physically comprised of one or more storage devices such as storage arrays. A storage array is a logical grouping of individual storage devices, such as a hard disk. In certain embodiments, storage **230** is comprised of a JBOD (Just a Bunch of Disks) array or a RAID (Redundant Array of Independent Disks) array. A collection of physical storage arrays may be further combined to form a rank, which dissociates the physical storage from the logical configuration. The storage space in a rank may be allocated into logical volumes, which define the storage location specified in a write/read request.

In one embodiment, by way of example only, the storage system as shown in FIG. **2** may include a logical volume, or simply "volume," may have different kinds of allocations. Storage **230***a*, **230***b* and **230***n* are shown as ranks in data storage system **200**, and are referred to herein as rank **230***a*, **230***b* and **230***n*. Ranks may be local to data storage system **200**, or may be located at a physically remote location. In other words, a local storage controller may connect with a remote storage controller and manage storage at the remote location. Rank **230***a* is shown configured with two entire volumes, **234** and **236**, as well as one partial volume **232***a*. Rank **230***b* is shown with another partial volume **232***b*. Thus volume **232** is allocated across ranks **230***a* and **230***b*. Rank **230***n* is shown as being fully allocated to volume **238**—that is, rank **230***n* refers to the entire physical storage for volume **238**. From the above examples, it will be appreciated that a rank may be configured to include one or more partial and/or entire volumes. Volumes and ranks may further be divided into so-called "tracks," which represent a fixed block of storage. A track is therefore associated with a given volume and may be given a given rank.

The storage controller **240** may include operation software **250**, a network monitoring module **242**, an analysis module **254**, and a notification module **256**. The operation software **250**, network monitoring module **242**, analysis module **254**, and notification module **256** may work in conjunction with each and every component of the storage controller **240**, the hosts **210**, **220**, **225**, and storage devices **230**. The operation software **250**, network monitoring module **242**, analysis module **254**, and notification module **256** may be structurally one complete module or may be associated and/or included with other individual modules. The operation software **250**, network monitoring module **242**, analysis module **254**, and notification module **256** may also be located in the cache **245** or other components of portion **200**.

The operation software **250**, network monitoring module **242**, analysis module **254**, and notification module **256** may individually and/or collectively perform various aspects of the present invention as will be further described. For example, the operation software **250** may contain executable code for performing network test and evaluation functionality. The network monitoring module **252** may implement one or more monitoring processes. The network monitoring module **252** may monitor individual SAN components and/or data transmission between SAN components. For example, network monitoring module **252** may monitor data exchanges across particular data communication paths. The analysis module **254** may be used to aid in detecting hardware and network failures will be further described. Finally, the notification module **256** may send notification messages to other components in the portion **200** or elsewhere about various network status.

The storage controller **240** includes a control switch **241** for controlling the fiber channel protocol to the host computers **210**, **220**, **225**, a microprocessor **242** for controlling all the storage controller **240**, a nonvolatile control memory **243** for storing a microprogram (operation software) **250** for controlling the operation of storage controller **240**, data for control, cache **245** for temporarily storing (buffering) data, and buffers **244** for assisting the cache **245** to read and write data, a control switch **241** for controlling a protocol to control data transfer to or from the storage devices **230**, and other components in the storage controller **240**. Multiple buffers **244** may be implemented with the present invention to assist with the operations as described herein. In one embodiment, the cluster hosts/nodes, **210**, **220**, **225** and the storage controller **240** are connected through a network adaptor (this could be a fibre channel) **260** as an interface i.e., via at least one switch called "fabric."

In view of the exemplary hardware structures depicted in FIGS. **1** and **2** previously, the mechanisms of the present invention may, as one of ordinary skill in the art will appreciate, be implemented and/or utilized in a wide variety of physical locations including, but not limited to Host-Bus Adapters (HBAs), Converged Network Adapters (CNAs), switch ports, storage ports, and the like.

As aforementioned, the mechanisms of the illustrated embodiments, among other functionality, provide the ability to isolate the source side of a failure between a first node and a connected appliance, or virtual appliance. Continuing to FIG. **3**, a method **300** of one embodiment of the present invention illustrates the methodologies herein. Beginning at step **302**, component failures are isolated by deploying a diagnostic code within the OS of a first node, and a connected appliance, and a diagnostic test is executed to determine if the source of the failure is within the first node or the connected appliance (step **304**). The method ends (step **306**).

In one embodiment, a flexible diagnostic kit is created that is platform-agnostic, that is, the diagnostic kit is able to execute on a wide variety of operating systems (typically supplied by a customer), in addition to an appliance or virtual appliance (typically supplied by a vendor). The diagnostic kit contains diagnostic code embodied within that relies on basic OS code built into any readily available OS that may be running on the first node. As the diagnostic kit executes, if an error or failure is detected, the diagnostic kit may be re-executed on a freshly installed version of the OS to attempt to reproduce the found error. If, when re-executed, the diagnostic kit detects the same error on a freshly installed OS environment, it is perspicuous that the source of the failure is within the customer, or user-side, of the environment. Similarly, the diagnostic kit may indicate the failure to be within the connected appliance or virtual appliance, in which responsibility then falls on the vendor of the appliance or virtual appliance.

FIG. **4** illustrates a method **400** for implementing the mechanisms of the present invention into a computing environment. Beginning at **402**, a platform-agnostic diagnostic kit containing diagnostic code is embodied upon a first node, a connected appliance, or both (step **404**). In one embodiment, the OS containing the diagnostic kit may be deployed automatically through a deployment kit included with a connected appliance or virtual appliance (step **406**). In another embodiment, the diagnostic kit may be embodied upon any computer readable storage medium as will be further described. During the deployment of the appliance or virtual appliance, a set of diagnostic tests are executed using the diagnostic code, from within the appliance (step **408**). If an error or failure is not indicated by the set of diagnostic tests (step **410**), the method ends (step **414**). If an error or failure is detected by the set of diagnostic tests (step **410**), the set of diagnostic tests is then re-executed in a freshly or "cleanly" installed OS for determining if the failure originates within the node's OS environment, or originates within the connected appliance or virtual appliance (step **412**). Here again, if the set of diagnostic tests, re-executed within a cleanly installed version of the OS, indicates the same error or failure, it is perspicuous that the source of the failure is within the customer, or user-side, of the environment. Similarly, the diagnostic kit may indicate the failure to be within the connected appliance or virtual appliance, in which responsibility then falls on the vendor of the appliance or virtual appliance. The method ends (step **414**).

In another embodiment, if an error is found to be within the first node or first node's OS environment, a diagnostic shell and set of tools may be included for further aid in failure investigation. A diagnostic script may further be included that may be read and analyzed to enhance the user's confidence in the validity of the overall diagnostic results.

Here again, the diagnostic kit containing the diagnostic code may be executed from within a supplied appliance automatically, the code being embedded within the supplied appliance, or may be executed from within a generic OS using any applicable user interface (UI).

The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including

instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

While one or more embodiments of the present invention have been illustrated in detail, the skilled artisan will appreciate that modifications and adaptations to those embodiments may be made without departing from the scope of the present invention as set forth in the following claims.

What is claimed is:

1. A method for detecting network and hardware failures in a computing environment, by a processor device, comprising:

isolating component failures by deploying a diagnostic code within an Operating System (OS) of both a first node and a connected appliance, and executing a set of diagnostic tests using the diagnostic code to determine if the source of the failure is within the first node or the connected appliance; and

executing the set of diagnostic tests during the deployment of the connected appliance, the set of diagnostic tests configured to execute from within the connected appliance.

2. The method of claim **1**, further including implementing a platform agnostic diagnostic kit containing the diagnostic code, the diagnostic kit configured to execute on one of the first node and the connected appliance.

3. The method of claim **2**, wherein the diagnostic kit containing the diagnostic code is deployed into the OS automatically, without user intervention.

4. The method of claim **2**, wherein the diagnostic kit containing the diagnostic code is deployed into the OS manually by a user, using a User Interface (UI).

5. The method of claim **1**, further including, if the executed set of diagnostic tests indicates a failure, re-executing the set of diagnostic tests on a freshly installed version of the OS, and comparing results of the set of diagnostic tests executed on the freshly installed version of the OS to the results of the set of diagnostic tests executed on the first node or connected appliance under test.

6. The method of claim **1**, wherein the connected appliance is a virtual appliance.

7. A system for detecting network and hardware failures in a computing environment, comprising:

a first node,

a connected appliance, and

a processor device, wherein the processor device:

isolates component failures by deploying a diagnostic code within an Operating System (OS) of both the first node and the connected appliance, and executes a diagnostic test using the diagnostic code to determine if the source of the failure is within the first node or the connected appliance; and

executes the set of diagnostic tests during the deployment of the connected appliance, the set of diagnostic tests configured to execute from within the connected appliance.

8. The system of claim **7**, wherein the processor device implements a platform agnostic diagnostic kit containing the diagnostic code, the diagnostic kit configured to execute on one of the first node and the connected appliance.

9. The system of claim **8**, wherein the diagnostic kit containing the diagnostic code is deployed into the OS automatically, without user intervention.

10. The system of claim **8**, wherein the diagnostic kit containing the diagnostic code is deployed into the OS manually by a user, using a User Interface (UI).

11. The system of claim **7**, wherein the processor device, if the executed set of diagnostic tests indicates a failure, re-executes the set of diagnostic tests on a freshly installed version of the OS, and compares results of the set of diagnostic tests executed on the freshly installed version of the OS to the results of the set of diagnostic tests executed on the first node or connected appliance under test.

12. The system of claim **7**, wherein the connected appliance is a virtual appliance.

13. A computer program product for detecting network and hardware failures in a computing environment, by a processor device, the computer program product embodied on a non-transitory computer-readable storage medium having computer-readable program code portions stored therein, the computer-readable program code portions comprising:

a first executable portion that isolates component failures by deploying a diagnostic code within an Operating System (OS) of both a first node and a connected appliance, and executes a diagnostic test using the diagnostic code to determine if the source of the failure is within the first node or the connected appliance; and

a second executable portion that executes the set of diagnostic tests during the deployment of the connected appliance, the set of diagnostic tests configured to execute from within the connected appliance.

14. The computer program product of claim **13**, further including a third executable portion that implements a platform agnostic diagnostic kit containing the diagnostic code, the diagnostic kit configured to execute on one of the first node and the connected appliance.

15. The computer program product of claim **14**, wherein the diagnostic kit containing the diagnostic code is deployed into the OS automatically, without user intervention.

16. The computer program product of claim **14**, wherein the diagnostic kit containing the diagnostic code is deployed into the OS manually by a user, using a User Interface (UI).

17. The computer program product of claim **13**, further including a third executable portion that, if the executed set

of diagnostic tests indicates a failure, re-executes the set of diagnostic tests on a freshly installed version of the OS, and compares results of the set of diagnostic tests executed on the freshly installed version of the OS to the results of the set of diagnostic tests executed on the first node or connected appliance under test.

18. The computer program product of claim **13**, wherein the connected appliance is a virtual appliance.

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