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(54) **VALIDATING STORED COPIES OF DATA IMAGES TO LOAD INTO MEMORY**

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(57) **ABSTRACT**

Provided are a method, system, and article of manufacture for validating stored copies of data images to load into memory. An image of data is maintained in a memory, wherein the image in the memory includes a generation number. The image in the memory is written to at least two copies of the image to storage locations in response to a first event, wherein the generation number for the image in the memory is stored in the storage locations having the copies of the image. A check generation number is stored in a storage location. The image is loaded from at least one of the copies of the image in one of the storage locations to the memory in response to a second event. The generation number for the image loaded into the memory. The check generation number is incremented in response to the second event. The generation numbers for the copies of the image in the storage locations and the check generation number are used to validate the copies of the image.

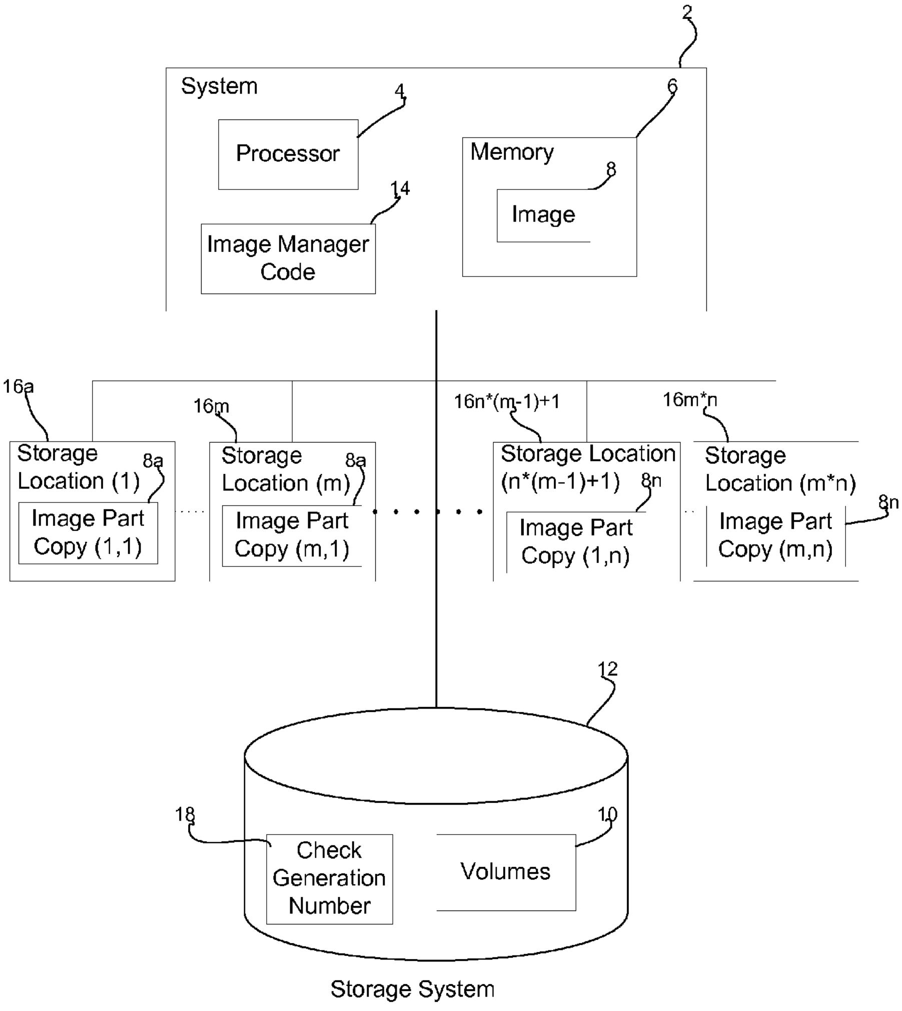


FIG. 1

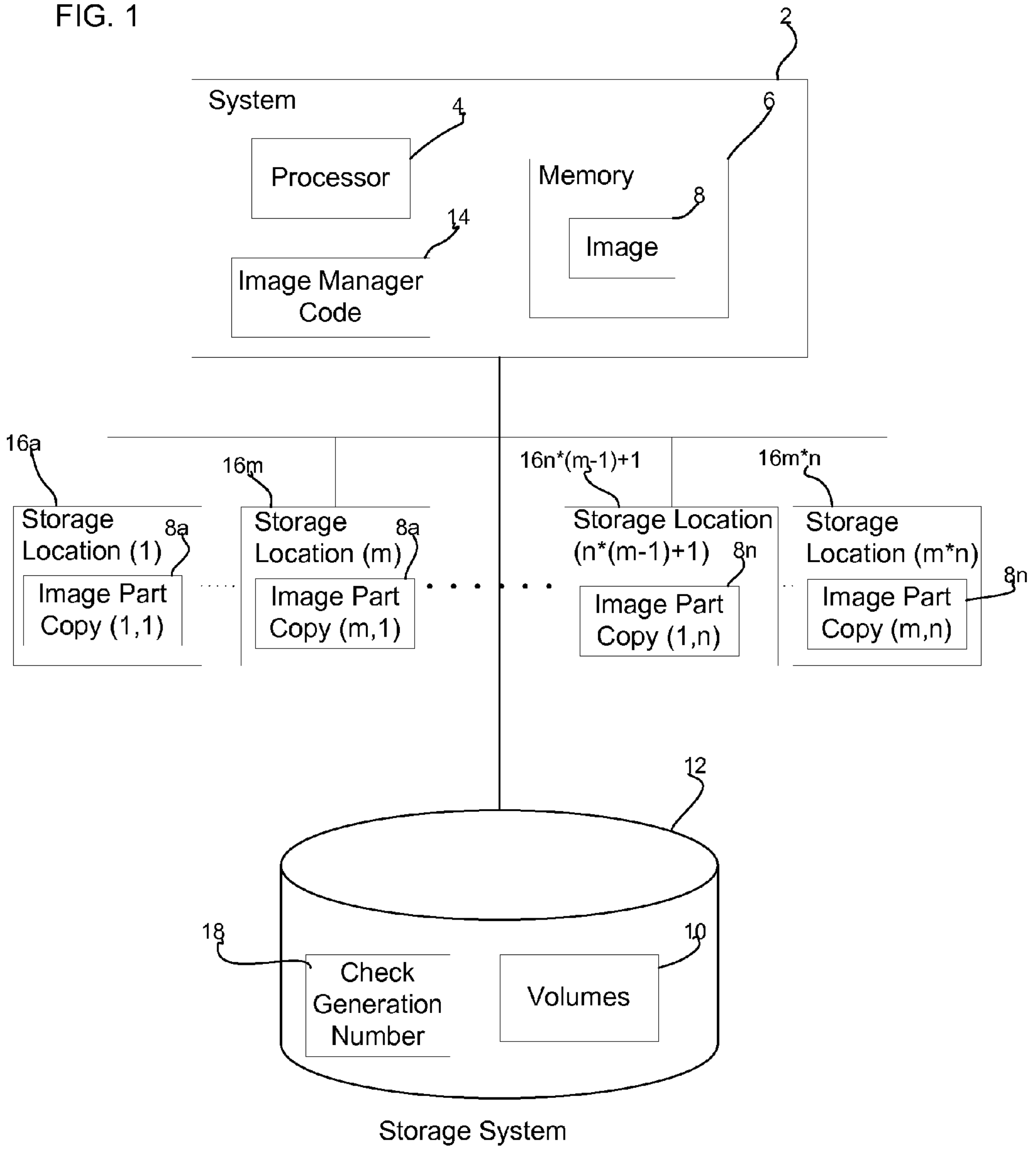

2
System
4
Processor
6
Memory
8
Image
14
Image Manager Code
16a
Storage Location (1)
8a
Image Part Copy (1,1)
16m
Storage Location (m)
8a
Image Part Copy (m,1)
16n*(m-1)+1
Storage Location (n*(m-1)+1)
8n
Image Part Copy (1,n)
16m*n
Storage Location (m*n)
8n
Image Part Copy (m,n)
12
18
Check Generation Number
10
Volumes
Storage System

FIG. 2

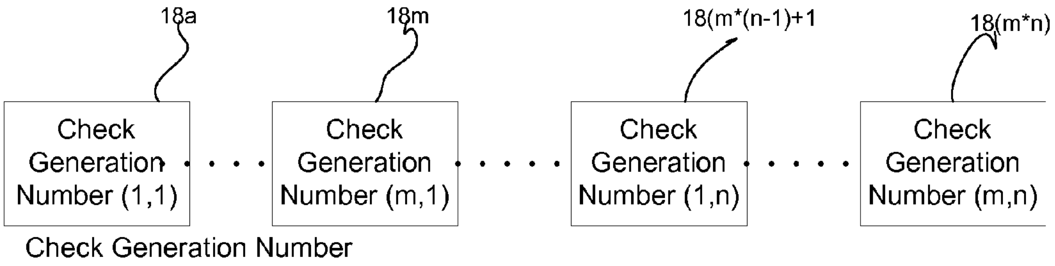
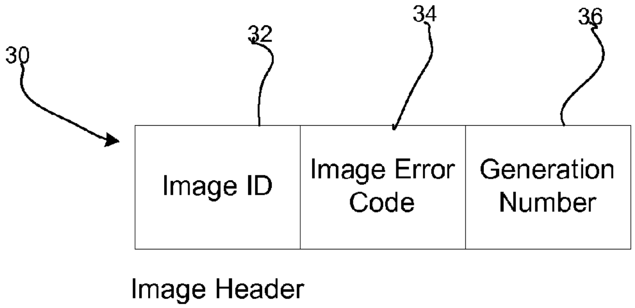

18a
18m
18(m*(n-1)+1
18(m*n)
Check Generation Number (1,1)
Check Generation Number (m,1)
Check Generation Number (1,n)
Check Generation Number (m,n)
Check Generation Number

FIG. 3


30
32
34
36
Image ID
Image Error Code
Generation Number
Image Header

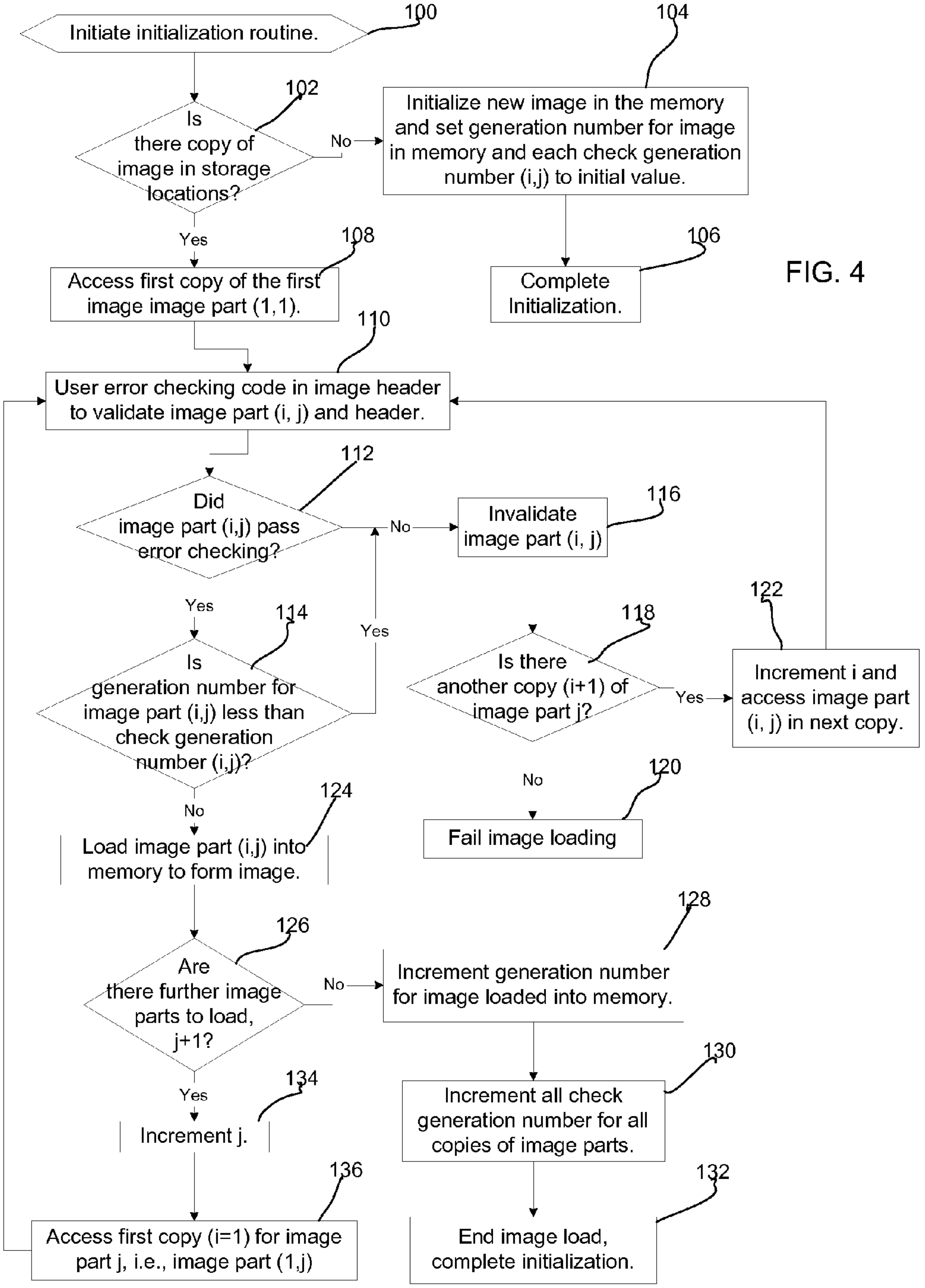

Initiate initialization routine.
100
Is there copy of image in storage locations?
102
No
Initialize new image in the memory and set generation number for image in memory and each check generation number (i,j) to initial value.
104
Yes
Access first copy of the first image image part (1,1).
108
Complete Initialization.
106
User error checking code in image header to validate image part (i, j) and header.
110
Did image part (i,j) pass error checking?
112
No
Invalidate image part (i, j)
116
Yes
Is generation number for image part (i,j) less than check generation number (i,j)?
114
Yes
Is there another copy (i+1) of image part j?
118
Yes
Increment i and access image part (i, j) in next copy.
122
No
Fail image loading
120
No
Load image part (i,j) into memory to form image.
124
Are there further image parts to load, j+1?
126
No
Increment generation number for image loaded into memory.
128
Yes
Increment j.
134
Increment all check generation number for all copies of image parts.
130
Access first copy (i=1) for image part j, i.e., image part (1,j)
136
End image load, complete initialization.
132

FIG. 4

FIG. 5

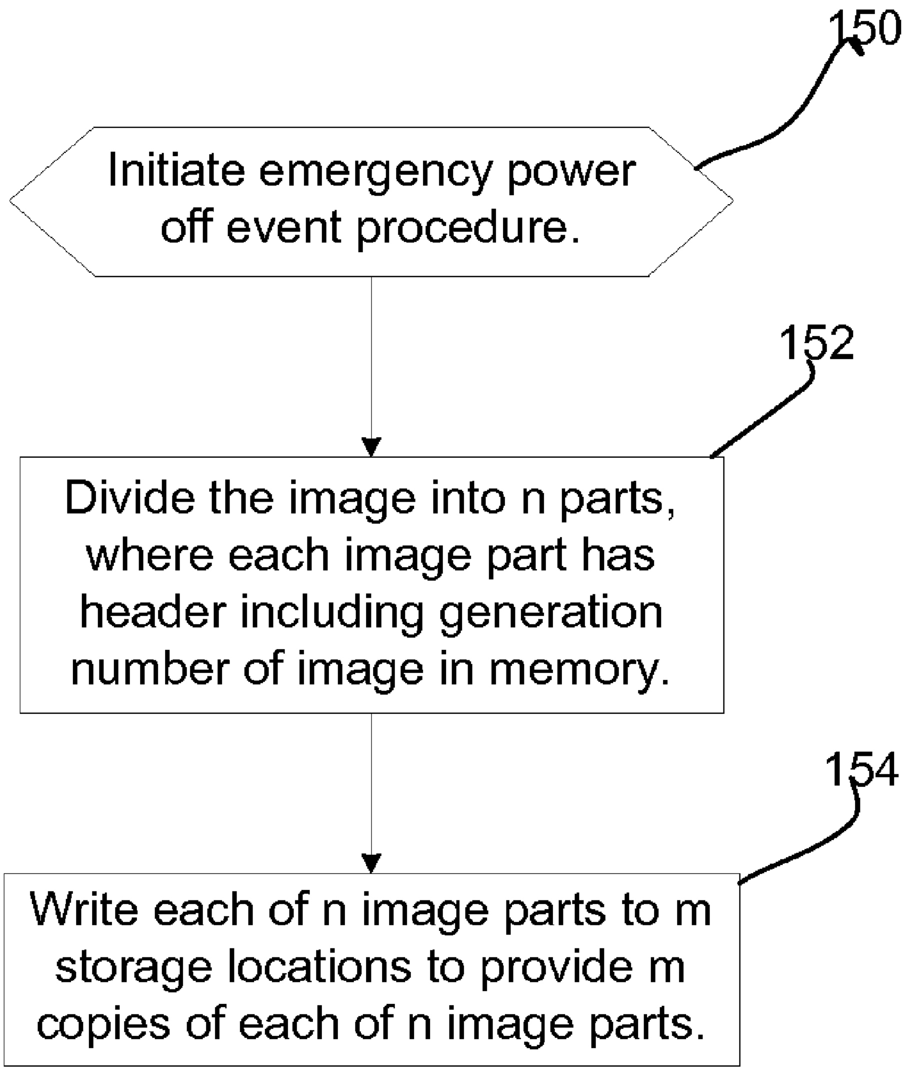
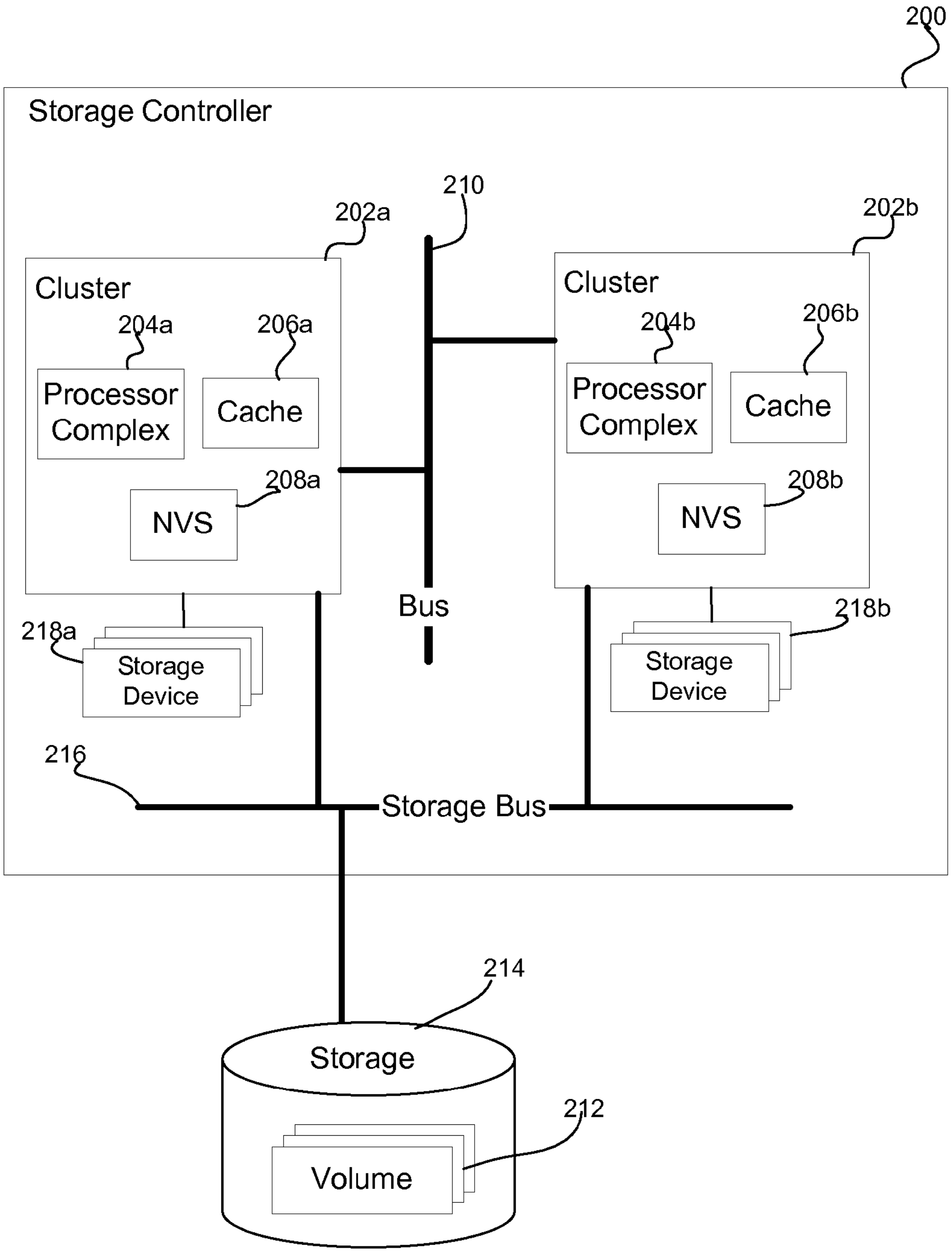

150
Initiate emergency power off event procedure.
152
Divide the image into n parts, where each image part has header including generation number of image in memory.
154
Write each of n image parts to m storage locations to provide m copies of each of n image parts.

FIG. 6


200
Storage Controller
210
202a
202b
Cluster
204a
206a
Processor Complex
Cache
208a
NVS
Cluster
204b
206b
Processor Complex
Cache
208b
NVS
Bus
218a
Storage Device
218b
Storage Device
216
Storage Bus
214
Storage
212
Volume

VALIDATING STORED COPIES OF DATA IMAGES TO LOAD INTO MEMORY

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method, system, and article of manufacture for validating stored copies of data images to load into memory.

[0003] 2. Description of the Related Art

[0004] During an Initial Microcode Load (IML), a processor may load a copy of the previous data image, including updates and other data, into cache. The processor may have previously stored a copy of the data image during an emergency power-off event or a cold or hard restart. This copy of the data image may be loaded into the memory to restore the system to the state before the power cycle.

[0005] In certain dual cluster systems, one cluster may store the data in the other cluster's cache in a non-volatile storage (NVS). The data for the other cluster's cache may be written from the NVS in the other cluster to a dedicated storage device. When one cluster initiates an IML, it may load its cache data image from the storage devices to which the other cluster wrote the cache image. Further, the data image from one cluster maintained in the NVS in the other cluster may be written from the NVS to storage devices for both clusters to provide multiple copies of the data image in both clusters.

SUMMARY

[0006] Provided are a method, system, and article of manufacture for validating stored copies of data images to load into memory. An image of data is maintained in a memory, wherein the image in the memory includes a generation number. The image in the memory is written to at least two copies of the image to storage locations in response to a first event, wherein the generation number for the image in the memory is stored in the storage locations having the copies of the image. A check generation number is stored in a storage location. The image is loaded from at least one of the copies of the image in one of the storage locations to the memory in response to a second event. The generation number for the image loaded into the memory. The check generation number is incremented in response to the second event. The generation numbers for the copies of the image in the storage locations and the check generation number are used to validate the copies of the image.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** illustrates an embodiment of a computing environment.

[0008] FIG. **2** illustrates an embodiment of check generation number.

[0009] FIG. **3** illustrates an embodiment of an image header.

[0010] FIG. **4** illustrates an embodiment of operations to load an image into memory.

[0011] FIG. **5** illustrates an embodiment of operations to write an image to storage locations.

[0012] FIG. **6** illustrates an embodiment of a dual cluster storage controller environment.

DETAILED DESCRIPTION

[0013] FIG. **1** illustrates an embodiment of a computing environment. A system **2** includes a processor **4** and a memory **6** that has a data image **8**. The data image **8** may include updates to volumes **10** in a storage system **12**. The image **8** may also include system configuration information. Image manager code **14** includes code that is executed by the processor **4** to manage the image **8** in the memory **6** in response to certain events, such as during a system initialization (e.g., IML) or early power-off warning (e.g., EPOW). For instance, the image manager code **14** may be implemented in the Initial Microcode Load (IML) code or the early power-off warning (EPOW) code that is executed.

[0014] To manage the image **8**, the image manager code **14** may store copies of the image within storage locations. In one embodiment, the image manager code **14** may store multiple copies of the entire image **8** into one or more storage locations. In another embodiment, the image manager code **14** may divide the image **8** into image parts **8***a* . . . . **8***n*, where n may be any integer greater than or equal to two. The copies then comprise the m copies of each image part **8***a* . . . **8***n* stored in the storage locations **16***a* . . . **16**(*m***n*). There may be one or more (m) copies of the image parts **8***a* . . . **8***n*. Each storage location **16***a* . . . . **16**(*m***n*) may comprise a separate non-volatile storage device, such as a disk drive, non-volatile electronic storage device (e.g., a Flash Memory, battery backed up Random Access Memory (RAM), etc.) or other suitable non-volatile storage medium. For instance, each of the m copies of an image part **8***a* . . . **8***n* may be stored in one of the m*n storage locations, where only one copy of one image part **8***a* . . . **8***n* is stored in one storage location, i.e., each storage location is dedicated to one image part copy. In this way, if the storage locations comprise separate storage devices where each storage device includes only one copy of one image part, then one image part **8***a* . . . **8***n* may be recovered from multiple storage locations.

[0015] The storage **12** may comprise a single storage device or an array of storage devices, such as a Just a Bunch of Disks (JBOD), Direct Access Storage Device (DASD), Redundant Array of Independent Disks (RAID) array, virtualization device, tape storage, flash memory

[0016] The image manager code **14** may maintain a mapping of each image part copy (i, j), where i indicates the copy number and j is the image part, and the storage location storing that particular image part copy (i, j). As discussed, in one embodiment, there may be multiple image parts **8***a* . . . **8***n* if the image **8** is divided. Alternatively, the image part may comprise the entire image **8**, where multiple copies of the entire image **8** are stored in multiple storage locations.

[0017] The image manager code **14** writes a generation number for the image **8** in the memory **6** to a check generation number **18** value stored in the storage system **12** or some other storage location. Further, a copy of the generation number is stored with each copy of the image part (i,j) stored in a storage location **16***a* . . . . **16**(*m***n*).

[0018] FIG. **2** illustrates an embodiment of the check generation number **18** stored in the storage system **12** as including a separate check generation number **18***a* . . . . **18**(*m***n*) for each image part copy (i, j), where there is one check generation number (i, j) for each image part copy (i, j), where "i" indicates the copy number of m copies and "j" indicates one of the n image parts. In an alternative embodiment, there may not be a separate check generation number for each image part copy (i, j), and instead there may be one or more check generation numbers for multiple image part copies.

[0019] FIG. **3** illustrates an embodiment of an image header **30** that may be included in the image **8** in the memory **6** and in each image part copy stored in a storage location **16***a* . . . **16**(*m**n), where an image part comprises a portion or the entire image **8**. The image header **30** includes an image identifier **32**, an image error code **34**, such as an error correction code for the image header **30** and image part, and a generation number **36** for the image part **8** or **8***a* . . . . **8***n*. In an alternative embodiment, the header information **30** and/or generation number **36** may be stored separately from the image part **8**, **8***a* . . . . **8***n*, but may be stored in the same storage location storing the image part **8***a* . . . **8***n* or image **8**.

[0020] FIG. **4** illustrates an embodiment of operations performed by the image manager code **14**, which may be code that is part of the system initialization code or IML. Upon initiating (at block **100**) system initialization, if (at block **102**) there is no stored copy of image parts in storage locations **16***a* . . . . **16**(*m*n*), then the image manager code **14** initializes (at block **104**) a new image **8** in the memory **6** and sets the generation number **36** for the image **8** in the memory **6** to an initial generation number value, where the generation number **36** may be included in the image **8** header **30**. The check generation number (i,j) for each copy i and image part j that will be created is set to the initial generation number. After setting the generation number for the image **8** and the check generation numbers, the initialization routine may then continue (at block **106**) until completion.

[0021] If (at block **102**) there are stored image part copies (i, j) in the storage locations **16***a* . . . **16**(*m*n*), then the image manager code **14** accesses (at block **104**) the first copy (i=1) of the first image part (j=1), i.e., image part copy **16***a*. The error checking code **34** in the image header **30** for the accessed image part copy (i, j) is then used (at block **110**) to validate the image part (i, j) and its header **30**. If (at block **112**) the image part copy (i,j) is validated using the image error code **34**, then a determination is made (at block **114**) as to whether the generation number **36** for image part copy (i,j) is less than the check generation number (i, j) in the storage system **12**. If (at block **114**) the generation number **36** for the image part copy (i,j) is less than the check generation number (i,j), then the image part copy (i,j) in the storage location has become outdated, as indicated by the higher check generation number (i, j), perhaps as a result of the storage location having the image part copy (i, j) being unavailable during the last update of the image part copy (i, j).

[0022] If (at block **112**) the image part copy (i,j) did not pass the error checking code **34** or its generation number **36** indicated (from the yes branch of block **114**) that the image part (i,j) was outdated, then the image part copy (i,j) in the storage location is invalidated (at block **116**). If (at block **118**) there is no additional copy (i+1) of image part j, then the image part j cannot be recovered and the image loading will fail (at block **120**). Otherwise, if (at block **118**) there is an additional copy (i+1) of the image part j, then "i" is incremented (at block **122**) and the next image part (i, j) is accessed to consider. Control proceeds back to block **110** to validate the next copy of the image part (i, j). If (at block **114**) the image part copy (i, j) is current, i.e., the generation number **36** for the image part copy (i, j) is equal to the corresponding check generation number (i, j), then that image part copy (i,j) is loaded (at block **124**) into the memory **6**.

[0023] If (at block **126**) there are no further image parts, e.g., j+1, that need to be loaded into the memory **6** to complete the image **8**, then the image manager code **14** increments (at block **128**) the generation number **36** for the complete image **8** loaded into the memory **8**, where the generation number **36** may be maintained in the image header **30** for the entire image **8**. The check generation numbers **18***a* . . . . **18**(*m**n) for all image part copies (**1**,**1**) . . . (m,n) are incremented (at block **130**) and the image load completes (at block **132**) and the initialization may continue. At this point, the generation number of the image **8** in the memory **6** and the check generation numbers for the image are greater than the generation numbers **36** included with the image part copies (i, j) in the storage locations **16***a* . . . **16**(*m*n*).

[0024] If (at block **126**) there are further image parts, e.g., j+1, to load, then "j" is incremented (at block **134**) and the image manager code **14** accesses (at block **136**) the first copy (i=1) for image part j, i.e., image part (**1**,j) and proceeds back to block **110** to validate the next image part j to load.

[0025] FIG. **5** illustrates an embodiment of operations performed by the image manager code **14** to write the image parts **8***a* . . . . **8***n* to the storage locations **16***a* . . . . **16**(*m*n*) in response to a second event, which in the described embodiments comprises an emergency power-off event. In response to initiating a power-off event procedure (at block **150**), the image manager code **14** divides (at block **152**) the image into n parts, where each image part **8***a* . . . . **8***n* has a header **30** including a generation number **36** that is the generation number of the image **8** in the memory **6**. Each of the n image parts is written (at block **154**) to m storage locations to provide m copies of each of the n image parts in m*n or fewer storage locations. In certain occurrences, some of the storage locations **16***a* . . . **16**(*m*n*) may be unavailable and, thus, not receive the image part copy having the current generation number.

[0026] With the described operations of FIGS. **4** and **5**, multiple copies of the image **8** or image parts **8***a* . . . **8***n* may be stored in separate storage locations or storage devices. In this way, if one of the storage locations becomes unavailable while the current image part is being written to the storage locations, that current image part may be recovered from another copy in another storage location. If the generation number for an image part copy is less than the check generation number for that image part, then the image part copy in the storage location has become outdated because its generation number is less than the current image generation number. This allows the image manager code **14** to determine if an image part in a storage location is outdated and cannot be used to recover the image during the image load into the memory **8**.

[0027] FIG. **6** illustrates an embodiment of a storage controller **200** having clusters **202***a*, **202***b*, each having two processor complexes **204***a*, **204***b*, a cache **206***a*, **206***b* to cache data and Input/Output (I/O) requests, and non-volatile storages (NVSs) **208***a*, **208***b*, such that data in caches **206***a* and **206***b* is cached in the NVS **208***b* and **208***b*, respectively, in the other cluster **202***a*, **202***b* via a bus **210**. Further, data from the caches **206***a*, **206***b* is destaged to volumes **212** in storage **214** via storage bus **216**. In this way, each cluster **202***a*, **202***b* comprises processing systems on different power boundaries and implemented in separate hardware components, such as separate motherboards. The storage **214** may comprise an array of storage devices, such as a Just a Bunch of Disks (JBOD), Direct Access Storage Device (DASD), Redundant Array of Independent Disks (RAID) array, virtualization device, tape storage, flash memory

[0028] Copies of the image maintained in the NVSs **208***a*, **208***b* may be stored in the storage devices **218***a*, **218***b* according to the operations described above with respect to FIGS. **1**, **2**, **3**, and **4**. One cluster **202***a*, **202***b* during initialization may load an image into its cache **206***a*, **206***b* from the storage devices **218***b*, **218***a*, respectively, in the other cluster **202***b*, **202***a*. The storage **214** may store the check generation numbers for the image part copies stored in the storage devices **218***a*, **218***b*. In this way, the image to load into the cache **206***a*, **206***b* for one cluster **202***a*, **202***b* is stored in another cluster. Further, each cluster **202***a*, **202***b* may store the data image of its memory **206***a*, **206***b* in the storage devices **218***a*, **218***b* of both clusters **202***a*, **202***b*.

ADDITIONAL EMBODIMENT DETAILS

[0029] The described operations may be implemented as a method, apparatus or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof. The described operations may be implemented as code maintained in a "computer readable medium", where a processor may read and execute the code from the computer readable medium. A computer readable medium may comprise media such as magnetic storage medium (e.g., hard disk drives, floppy disks, tape, etc.), optical storage (CD-ROMs, DVDs, optical disks, etc.), volatile and non-volatile memory devices (e.g., EEPROMs, ROMs, PROMs, RAMs, DRAMs, SRAMs, Flash Memory, firmware, programmable logic, etc.), etc. The code implementing the described operations may further be implemented in hardware logic (e.g., an integrated circuit chip, Programmable Gate Array (PGA), Application Specific Integrated Circuit (ASIC), etc.). Still further, the code implementing the described operations may be implemented in "transmission signals", where transmission signals may propagate through space or through a transmission media, such as an optical fiber, copper wire, etc. The transmission signals in which the code or logic is encoded may further comprise a wireless signal, satellite transmission, radio waves, infrared signals, Bluetooth, etc. The transmission signals in which the code or logic is encoded is capable of being transmitted by a transmitting station and received by a receiving station, where the code or logic encoded in the transmission signal may be decoded and stored in hardware or a computer readable medium at the receiving and transmitting stations or devices. An "article of manufacture" comprises computer readable medium, hardware logic, and/or transmission signals in which code may be implemented. A device in which the code implementing the described embodiments of operations is encoded may comprise a computer readable medium or hardware logic. Of course, those skilled in the art will recognize that many modifications may be made to this configuration without departing from the scope of the present invention, and that the article of manufacture may comprise suitable information bearing medium known in the art.

[0030] In the described embodiments, the image is loaded from storage locations and the generation number incremented as part of a first event comprising a system initialization, such as an IML, and the image is written to the storage locations in response to a second event comprising an emergency power-off event. In alternative embodiments, the first and second events may comprise events other than a system initialization and emergency power-off.

[0031] The terms "an embodiment", "embodiment", "embodiments", "the embodiment", "the embodiments", "one or more embodiments", "some embodiments", and "one embodiment" mean "one or more (but not all) embodiments of the present invention(s)" unless expressly specified otherwise.

[0032] The terms "including", "comprising", "having" and variations thereof mean "including but not limited to", unless expressly specified otherwise.

[0033] The enumerated listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise.

[0034] The terms "a", "an" and "the" mean "one or more", unless expressly specified otherwise.

[0035] Devices that are in communication with each other need not be in continuous communication with each other, unless expressly specified otherwise. In addition, devices that are in communication with each other may communicate directly or indirectly through one or more intermediaries.

[0036] A description of an embodiment with several components in communication with each other does not imply that all such components are required. On the contrary a variety of optional components are described to illustrate the wide variety of possible embodiments of the present invention.

[0037] Further, although process steps, method steps, algorithms or the like may be described in a sequential order, such processes, methods and algorithms may be configured to work in alternate orders. In other words, any sequence or order of steps that may be described does not necessarily indicate a requirement that the steps be performed in that order. The steps of processes described herein may be performed in any order practical. Further, some steps may be performed simultaneously.

[0038] When a single device or article is described herein, it will be readily apparent that more than one device/article (whether or not they cooperate) may be used in place of a single device/article. Similarly, where more than one device or article is described herein (whether or not they cooperate), it will be readily apparent that a single device/article may be used in place of the more than one device or article or a different number of devices/articles may be used instead of the shown number of devices or programs. The functionality and/or the features of a device may be alternatively embodied by one or more other devices which are not explicitly described as having such functionality/features. Thus, other embodiments of the present invention need not include the device itself.

[0039] The illustrated operations of FIGS. **4** and **5** show certain events occurring in a certain order. In alternative embodiments, certain operations may be performed in a different order, modified or removed. Moreover, steps may be added to the above described logic and still conform to the described embodiments. Further, operations described herein may occur sequentially or certain operations may be processed in parallel. Yet further, operations may be performed by a single processing unit or by distributed processing units.

[0040] The foregoing description of various embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto. The above specification, examples and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

What is claimed is:

1. An article of manufacture including code enabled to communicate with a memory and storage locations and to perform:

maintaining an image of data in a memory, wherein the image in the memory includes a generation number;

writing the image in the memory to at least two copies of the image to storage locations in response to a first event, wherein the generation number for the image in the memory is stored in the storage locations having the copies of the image;

storing in a storage location a check generation number;

loading the image from at least one of the copies of the image in one of the storage locations to the memory in response to a second event;

incrementing the generation number for the image loaded into the memory;

incrementing the check generation number in response to the second event; and

using the generation numbers for the copies of the image in the storage locations and the check generation number to validate the copies of the image.

2. The article of manufacture of claim **1**, wherein using the generation numbers comprises:

comparing the generation number for each copy of the image in one of the storage locations to the check generation number in response to the second event, wherein the image from one copy is not loaded from the storage location into the memory in response to determining that the generation number of the copy of the image in the storage location is less than the check generation number.

3. The article of manufacture of claim **1**, wherein writing the image in the memory to at least two copies comprises:

dividing the image in the memory into at least two parts of the image; and

writing each part of the image to at least one of the storage locations, wherein each part of the image written to one of the storage locations includes the generation number of the image in the memory.

4. The article of manufacture of claim **3**, wherein each storage location including one copy of one part of the image comprises a storage device, and wherein the storage location including the check generation number comprises a storage device not including any copy of any part of the image.

5. The article of manufacture of claim **4**, wherein the memory is in a first cluster and wherein the storage devices including the copies of the parts of the image are in a second cluster.

6. The article of manufacture of claim **4**, wherein each storage device includes only one copy of one part of the image.

7. The article of manufacture of claim **4**, wherein the parts of the image may be loaded from any validated copy of the parts image in the storage devices.

8. The article of manufacture of claim **3**, wherein the check generation number includes a separate check generation number for each copy of each part of the image, wherein the validation of one copy of one part of the image comprises comparing the check generation number for the copy of the part of the image with the generation number in the storage location including the copy of the part of the image.

9. The article of manufacture of claim **1**, wherein the first event comprises an emergency power-off event and wherein the second event comprises a system initialization.

10. A system, comprising:

a memory including an image of data, wherein the image in the memory includes a generation number;

storage locations;

a device implementing code that is operable for:

writing the image in the memory to at least two copies of the image to storage locations in response to a first event, wherein the generation number for the image in the memory is stored in the storage locations having the copies of the image;

storing in a storage location a check generation number;

loading the image from at least one of the copies of the image in one of the storage locations to the memory in response to a second event;

incrementing the generation number for the image loaded into the memory;

incrementing the check generation number in response to the second event; and

using the generation numbers for the copies of the image in the storage locations and the check generation number to validate the copies of the image.

11. The system of claim **10**, wherein using the generation numbers comprises:

comparing the generation number for each copy of the image in one of the storage locations to the check generation number in response to the second event, wherein the image from one copy is not loaded from the storage location into the memory in response to determining that the generation number of the copy of the image in the storage location is less than the check generation number.

12. The system of claim **10**, wherein writing the image in the memory to at least two copies comprises:

dividing the image in the memory into at least two parts of the image; and

writing each part of the image to at least one of the storage locations, wherein each part of the image written to one of the storage locations includes the generation number of the image in the memory.

13. The system of claim **12**, wherein each storage location including one copy of one part of the image comprises a storage device, and wherein the storage location including the check generation number comprises a storage device not including any copy of any part of the image.

14. The system of claim **13**, further comprising:

a first cluster including the memory; and

a second cluster including the storage devices having the copies of the parts of the image.

15. The system of claim **12**, wherein the check generation number includes a separate check generation number for each copy of each part of the image, wherein the validation of one copy of one part of the image comprises comparing the check generation number for the copy of the part of the image with the generation number in the storage location including the copy of the part of the image.

16. The system of claim **10**, wherein the first event comprises an emergency power-off event and wherein the second event comprises a system initialization.

17. A method, comprising:

maintaining an image of data in a memory, wherein the image in the memory includes a generation number;

writing the image in the memory to at least two copies of the image to storage locations in response to a first event, wherein the generation number for the image in the memory is stored in the storage locations having the copies of the image;

storing in a storage location a check generation number;

loading the image from at least one of the copies of the image in one of the storage locations to the memory in response to a second event;

incrementing the generation number for the image loaded into the memory;

incrementing the check generation number in response to the second event; and

using the generation numbers for the copies of the image in the storage locations and the check generation number to validate the copies of the image.

18. The method of claim **17**, wherein using the generation numbers comprises:

comparing the generation number for each copy of the image in one of the storage locations to the check generation number in response to the second event, wherein the image from one copy is not loaded from the storage location into the memory in response to determining that the generation number of the copy of the image in the storage location is less than the check generation number.

19. The method of claim **17**, wherein writing the image in the memory to at least two copies comprises:

dividing the image in the memory into at least two parts of the image; and

writing each part of the image to at least one of the storage locations, wherein each part of the image written to one of the storage locations includes the generation number of the image in the memory.

20. The method of claim **19**, wherein each storage location including one copy of one part of the image comprises a storage device, and wherein the storage location including the check generation number comprises a storage device not including any copy of any part of the image.

21. The method of claim **20**, wherein the memory is in a first cluster and wherein the storage devices including the copies of the parts of the image are in a second cluster.

22. The method of claim **19**, wherein the check generation number includes a separate check generation number for each copy of each part of the image, wherein the validation of one copy of one part of the image comprises comparing the check generation number for the copy of the part of the image with the generation number in the storage location including the copy of the part of the image.

23. The method of claim **17**, wherein the first event comprises an emergency power-off event and wherein the second event comprises a system initialization.

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