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(54) Title: WEAR LEVELING METHOD AND APPARATUS AND STORAGE MEDIUM CROSS-REFERENCE TO RELATED APPLICATIONS

(57) Abstract: A wear leveling method and apparatus and a storage medium are disclosed, the method including: performing error correction on data read from a physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, where the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with a residual service life of the physical block; detecting whether the obtained number of the corrected bits is more than a preset bit-number threshold value; and transferring data stored in the physical block, if the number of corrected bits is detected as more than the preset bit-number threshold value.

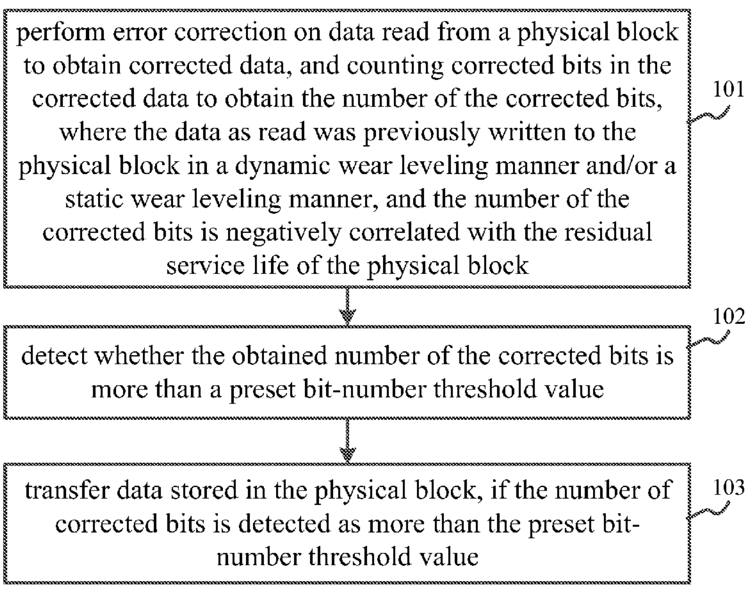

FIGURE 1

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WEAR LEVELING METHOD AND APPARATUS AND STORAGE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to Chinese Patent Application No. 201310505230.9, entitled "WEAR LEVELING METHOD AND APPARATUS", filed on October 23, 2013 by SHENZHEN TENCENT COMPUTER SYSTEM CO., LTD., the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates to the field of computer technologies, in particular, to a wear leveling method and apparatus, and a storage medium.

BACKGROUND

A Solid State Disk (SSD) is formed by an array of solid state electronic storage chips. In the case where NAND flashes are adopted as storage media in the SSD, before data is written to a physical block of the SSD, the original data in the physical block needs to be erased. Considering the limited allowable number of times of erasing in the physical block, the physical block will become invalid if the limited allowable number of times of erasing in the physical block is reached, and data loss occurs if the data is written to the invalid physical block. Therefore, to ensure data security, wear leveling of physical blocks in the SSD is performed to make the numbers of times of erasing in the physical blocks as even as possible, and to avoid the loss of data written to a certain physical block which has been erased for excessive times.

There are a dynamic wear leveling manner and a static wear leveling manner in the prior art. In the dynamic wear leveling manner, data is written to a free physical block which has been erased for a relatively small number of times, so that the physical block will be erased for more times because the data written to the physical block might be updated soon. In the static wear leveling manner, data to be updated in a relatively long update period is determined and then transferred to a free physical block which has been erased for a relatively large number of times, so that a physical block where the data is originally stored may be used for storing other data, which might be updated soon so that the physical block stored with said other data may be erased for more times.

It is assumed that the allowable number of times of erasing in each physical block in the SSD is the same as that in any other physical block in the SSD in the prior art, thus the number of times of erasing in each physical block of the SSD may be made even with that in the other physical blocks of the SSD by writing data to a physical block which has been erased for a relatively small number of times. However, due to factors such as the limitation of SSD manufacturing technique and mixed use of old and new SSDs, not all of the physical blocks share the same allowable number of times of erasing, instead, a certain physical block which has been erased for a relatively small number of times and selected for storing data might be provided with a relatively small allowable number of times of erasing, that is, the residual service life of the selected physical block may be shorter than that of a physical block which has been erased for more times, thus a data loss occurs when data is written to the selected physical block, thereby degrading data security.

For example, in the case where the allowable number of times of erasing in a free first physical block is 2000 and the allowable number of times of erasing in a free second physical block is 10000, if the first physical block has been erased for 1950 times and the second physical block has been erased for 2000 times, then data will be written to the first physical block that has been erased for less times instead of the second physical block which is provided with a larger allowable number of times of erasing, as a result, the current number of times of erasing in the first physical block is close to the allowable number of times of erasing in the first physical block, thereby degrading the security of data written to the first physical block.

SUMMARY

To avoid the case where a physical block erased for a small number of times that is selected for storing data might be provided with a small allowable number of times of erasing and hence the security of the data stored in the physical block is degraded, an embodiment of the present disclosure provides a wear leveling method and apparatus and a storage medium as follows.

In an aspect, an embodiment of the present disclosure provides a wear leveling method, including:

performing error correction on data read from a physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, wherein the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with a residual service life of the physical block;

detecting whether the obtained number of the corrected bits is more than a preset bit-number threshold value; and

transferring data stored in the physical block, if the number of the corrected bits is detected as more than the preset bit-number threshold value.

In another aspect, an embodiment of the present disclosure provides wear leveling apparatus, including:

a first obtaining module, which is configured to perform error correction on data read from a physical block to obtain corrected data and counting corrected bits in the corrected data to obtain the number of the corrected bits, wherein the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with a residual service life of the physical block;

a first detecting module, which is configured to detect whether the obtained number of the corrected bits is more than a preset bit-number threshold value; and

a transferring module, which is configured to transfer data stored in the physical block, if the number of the corrected bits is detected as more than the preset bit-number threshold value.

In still another aspect, an embodiment of the present disclosure provides a storage medium containing computer-readable instructions, where the computer-readable instructions, when being executed by a computer processor, are configured to perform a wear leveling method comprising steps of:

performing error correction on data read from a physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, wherein the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block;

detecting whether the obtained number of the corrected bits is more than a preset bit-number threshold value; and

transferring data stored in the physical block, if the number of corrected bits is detected as more than the preset bit-number threshold value.

In embodiments of the present invention, error correction is performed on data read from a physical block to obtain corrected data, and corrected bits in the corrected data are counted to obtain the number of the corrected bits, where the data as read was previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block; it is detected whether the obtained number of the corrected bits is more than the preset bit-number threshold value; and if the number of the corrected bits is detected as more than the preset bit-number threshold value, the data stored in the physical block is transferred, so that the wear leveling of the physical blocks in the SSD is implemented. Considering the fact that a larger number of corrected bits of data means a shorter residual service life of the physical block containing the data, and that the data is previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, the number of corrected bits may be employed to predict the residual service life of the physical block, and data stored in a physical block with a short residual service life is transferred to another physical block that has been erased for a relatively small number of times and has a longer residual service life, so that the case where a physical block erased for a small number of times that is selected for storing data might be provided with a small allowable number of times of erasing is avoided, and the security of data written to the physical block is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which form a part of the present disclosure, are intended to provide further explanation of the present disclosure. Exemplary embodiments of the present invention and illustration thereof are intended to explain the disclosure but not to improperly limit the disclosure. The drawings may be modified and substituted by those skilled in the art without any creative work, where

Figure 1 is a flowchart of a wear leveling method according to an embodiment of the present invention;

Figure 2 is a flowchart of a wear leveling method according to another embodiment of the present invention;

Figure 3 is a structural block diagram showing a wear leveling apparatus according to an embodiment of the present invention; and

Figure 4 is a structural block diagram showing a wear leveling apparatus according to another embodiment of the present invention.

DETAILED DESCRIPTION

It should be noted that embodiments of the present invention and features therein can be combined with each other if no conflict arises. The present disclosure will be illustrated in detail with reference to the drawings and in conjunction with the embodiments in order to make solutions and advantages of the present disclosure more apparent. The described particular embodiments are provided merely for explaining the disclosure, but not limiting the disclosure.

Referring to Figure 1 which shows a flowchart of a wear leveling method according to an embodiment of the present invention, and the wear leveling method, which may be applied to a Flash Translation Layer (FTL), includes the following Steps 101, 102 and 103.

At Step 101, error correction is performed on data read from a physical block to obtain corrected data, and corrected bits in the corrected data are counted to obtain the number of the corrected bits, where the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block. For example, when data consisting of eight bits “00110101” stored in a physical block in an SSD is read out as “00110110”, that is, last two bits of the data as read out are incorrect, error correction performed on the data as read out will correct these two incorrect bits to obtain corrected data “00110101”, thus the number of corrected bits is obtained as 2.

Because the data as read is written to physical blocks in the dynamic wear leveling manner and/or the static wear leveling manner in the embodiment, the numbers of times of erasing in all physical blocks are made as even as possible, to avoid the occurrence of certain excessively erased physical blocks in an SSD which causes invalidation of the SSD still containing numerous physical blocks not yet erased for up to the respective allowable times, so that the residual service life of the SSD is prolonged.

Herein, according to the dynamic wear leveling manner, frequently modified data or any data the modification frequency of which cannot be determined is written to a free physical block that has been erased for a relatively small number of times, and data that will not be modified for a long time is written to a free physical block that has been erased for a relatively large number of times.

According to the static wear leveling manner, a physical block containing data updated in a long update period is determined among occupied physical blocks, and the data in the determined physical block is transferred to a free physical block that has been erased for a relatively large number of times, so that the determined physical block then becomes free and may be subsequently used for storing other data that is modified more frequently.

In reading the data written in the dynamic wear leveling manner and/or the static wear leveling manner, data read from a physical block that has been erased for almost the corresponding allowable number of times might be incorrect and need be corrected. Generally, more bits of the data as read out are incorrect and hence more bits are corrected by an error correcting process performed on the data, if the current number of times of erasing in the physical block is closer to the corresponding allowable number of times of erasing. Therefore, the number of the corrected bits may be obtained to present the residual service life of the physical block.

At Step 102, it is detected whether the number of the corrected bits is more than a preset bit-number threshold value, and if the number of the corrected bits is detected as more than the preset bit-number threshold value, Step 103 is performed.

The bit-number threshold value refers to the minimal number of corrected bits for transferring the data stored in the physical block, and may be preset and modified as desired, which is not limited herein.

The case where the number of the corrected bits is more than the bit-number threshold value means that the physical block has been erased for almost up to the allowable number of times of erasing and the residual service life of the physical block is short, thus the physical block need be processed accordingly by proceeding with Step 103. On the contrary, the case where the number of the corrected bits is no more than the bit-number threshold value means that the physical block has been erased for far less than the allowable number of times of erasing and the residual service life of the physical block is long, thus the data stored in the physical block need not be transferred accordingly.

At Step 103, the data stored in the physical block is transferred. Because the physical block has been erased for almost up to the allowable number of times of erasing, the data stored in the physical block is transferred to another free physical block which has a long residual service life, to ensure data security.

As can be seen from the above, in the wear leveling method according to the present embodiment, error correction is performed on data read from a physical block to obtain corrected data, and corrected bits in the corrected data are counted to obtain the number of the corrected bits, where the data as read was previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block; it is detected whether the obtained number of the corrected bits is more than the preset bit-number threshold value; and if the number of the corrected bits is detected as more than the preset bit-number threshold value, the data stored in the physical block is transferred, so that the wear leveling of the physical blocks is implemented. Considering the fact that a larger number of corrected bits of data means a shorter residual service life of the physical block containing the data, and that the data is previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, the number of corrected bits may be employed to predict the residual service life of the physical block, and data stored in a physical block with a short residual service life is transferred to another physical block that has been erased for a relatively small number of times and has a longer residual service life, so that the case where a physical block erased for a small number of times that is selected for storing data might be provided with a small allowable number of times of erasing is avoided, and the security of data written to the physical block is improved.

Figure 2 shows a flowchart of a wear leveling method according to another embodiment of the present invention, and the wear leveling method may be applied to an FTL. The present embodiment is different from the preceding embodiment in that a step of writing data to a physical block of an SSD in the dynamic wear leveling manner and/or the static wear leveling manner is added, and after the data in the physical block is transferred, the data is erased from the physical block and the number of times of erasing in the physical block is modified, so that the number of times of erasing in each physical block of the SSD may be made more even with that in the other physical blocks of the SSD, and the service life of the SSD is further prolonged. The wear leveling method includes the following Steps 201 to 206.

At Step 201, it is detected whether an update period of data is longer than a preset period threshold value, and if it is detected that the update period of the data is longer than the preset period threshold value, Step 202 is performed.

In the present embodiment, the data is written to the physical block in the dynamic wear leveling manner; or among data written to physical blocks, data with a long update period that is written to a certain physical block is transferred in the static wear leveling manner to a physical block that has been erased for more times; or data is written to a physical block in the dynamic wear leveling manner, and data with a long update period that is written to a certain physical block is transferred in the static wear leveling manner to a physical block that has been erased for more times. Because the data is written to physical blocks in the dynamic wear leveling manner and/or the static wear leveling manner in the present embodiment, the number of times of erasing in each physical block is made as even as possible with that in the other physical blocks according to the numbers of times of erasing in all the physical blocks, to avoid the occurrence of certain excessively erased physical blocks in the SSD which causes invalidation of the SSD still containing numerous physical blocks not yet erased for up to the respective allowable times, so that the residual service life of the SSD is prolonged.

If data to be updated by a long update period is written to a physical block of an SSD, the data will be stored in the physical block for a long time and hence the number of times of erasing in this physical block will not be increased within the update period, so that the invalidation of the physical block is delayed to prolong the residual service life of the SSD. As such, in writing data to a physical block in the dynamic wear leveling manner and/or the static wear leveling manner, the data may be written to the physical block based on both the number of times of erasing in the physical block and the update period of the data.

In particular, it is detected whether the update period of the data is longer than the preset period threshold value. If it is detected that the update period of the data is longer than the preset period threshold value, Step 202 is performed to write the data to the physical block, and if it is detected that the update period of the data is less than or equal to the preset period threshold value, a physical block that has been erased for a less number of times is selected for storing the data.

In the present embodiment, considering the variety of update periods of data, a statistics of the update periods of the data is made according to property information of the data. For example, if an update period of data from a certain device is relatively long, while an update period of data from another device is relatively short, the update period of data may be determined from the source of the data. Likewise, if an update period of data of a certain type is relatively long, while an update period of data of another type is relatively short, the update period of data may be determined from the type of the data.

The present embodiment will be further described below by an example where the update period of data is determined from the type of the data. Particularly, a statistics of update periods of data to be written to physical blocks is made by types of the data, to determine at least one data type corresponding to a long update period, and generate a data type list according to the determined at least one data type. In an implementation, the data type list may be updated, so that the data type list is more adapted to use habits of a user, and the precision of the data type list may be improved. Here, the statistics of the update periods of the data made by types of the data may be implemented by: obtaining the type of data written to each physical block; making a statistics of update periods of data by each type of the data; and obtaining an average of the update periods of the data of each type as an update period of this type of data.

In an implementation of the present embodiment, detecting whether the update period of data is longer than the preset period threshold value includes:

1) obtaining the type of data;

2) detecting whether the type of the data is one from a preset data type list; and

3) determining that the update period of the data is longer than the preset period threshold value if it is detected that the type of the data is one from the preset data type list. In particular, before the data is written to a physical block, the type of the data is obtained and compared with data types in the preset data type list. If the type of the data is the same as one data type from the data type list, it is determined that the update period of the data is long, and Step 202 is performed; otherwise, if the type of the data is not present in the data type list, it is determined that the update period of the data is short, and a

physical block erased for a small number of times is selected for storing the data.

At Step 202, the data is written to a free physical block that has been erased for the most times.

Upon each operation on a physical block of an SSD, the maximal number of times of erasing, the minimal number of times of erasing, and an average number of times of erasing among all the physical blocks of the SSD are calculated and updated. Therefore, in the present step, the maximal number of times of erasing may be read out, a physical block that has been erased for a number of times that is the closest to the maximal number of times of erasing is searched out from free physical blocks, and the data is written to the physical block as searched out.

In the present embodiment, the numbers of times of erasing in the free physical blocks may be stored in a Red-Black tree. Because data stored in the Red-Black tree is sorted according to the value of the data, it is efficient to search for data of a certain value in the Red-Black tree, and hence the free physical block that has been erased for the most times may be searched out more efficiently, so that the efficiency in writing the data is improved.

At Step 203, error correction is performed on data read from a physical block to obtain corrected data, and corrected bits in the corrected data are counted to obtain the number of the corrected bits, where the data as read was previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block.

In reading the data written in the dynamic wear leveling manner and/or the static wear leveling manner, data read from a physical block that has been erased for almost the corresponding allowable number of times might be incorrect and need be corrected. Generally, more bits of the data as read out are incorrect and hence more bits are corrected by an error correcting process performed on the data, if the current number of times of erasing in the physical block is closer to the corresponding allowable number of times of erasing. Therefore, the number of the corrected bits may be obtained to present the residual service life of the physical block.

At Step 204, it is detected whether the obtained number of the corrected bits is more than a preset bit-number threshold value, and if the number of the corrected bits is detected as more than the preset bit-number threshold value, Step 205 is performed.

The bit-number threshold value refers to the minimal number of corrected bits for transferring the data stored in the physical block, and is generally positively correlated with the correction capability of an Error Correcting Code (ECC), which is represented by the maximal number of bits correctable by the ECC. For example, if the maximal number of bits correctable by the ECC is 30 bits per kilobyte, the bit-number threshold value may be preset as 20 or 25, and if the maximal number of bits correctable by the ECC is 10 bits per kilobyte, the bit-number threshold value may be preset as 6 or 8, which is not limited in the present embodiment. Herein, the maximal number of bits correctable by the ECC may be provided by a controller of the SSD.

The case where the number of the corrected bits is more than the bit-number threshold value means that the physical block has been erased for almost up to the allowable number of times of erasing and the residual service life of the physical block is short, thus the physical block need be processed accordingly by proceeding with Step 205. On the contrary, the case where the number of the corrected bits is no more than the bit-number threshold value means that the physical block has been erased for far less than the allowable number of times of erasing and the residual service life of the physical block is long, thus the data stored in the physical block need not be transferred accordingly.

At Step 205, the data stored in the physical block is transferred. Because the physical block has been erased for almost up to the allowable number of times of erasing, the data stored in the physical block is transferred to another free physical block which has a long residual service life, to ensure data security.

At Step 206, the data stored in the physical block is erased, and the number of times of erasing in the physical block is modified as the maximal one among the current numbers of times of erasing in all physical blocks of the SSD.

If the current number of times of erasing in the physical block is small, the increment of the number of times of erasing in the physical block may be increased to prevent the physical block from being selected again according to the number of times of erasing. For example, the number of times of erasing in the physical block may be increased by a preset value larger than 1, or the number of times of erasing in the physical block may be set as a preset value far larger than the current number of times of erasing in the physical block. The present embodiment is further described below by an example where the number of times of erasing in the physical block is set as a preset value.

In particular, the current maximal number of times of erasing in the SSD is read out, and the number of times of erasing in the physical block is modified as the current maximal number of times of erasing in the SSD. In this case, the data will not be written to this physical block so that the invalidation of this physical block is delayed and the residual service life of the SSD is prolonged, considering that the number of times of erasing in this physical block is the maximal and data will be written to a physical block erased for a relatively small number of times according to the dynamic wear leveling manner and/or the static wear leveling manner.

Furthermore, before modifying the number of times of erasing in the physical block, it is detected whether the number of times of erasing in the physical block is small. If the number of times of erasing in the physical block is small, the increment of the number of times of erasing in the physical block is increased; and if the number of times of erasing in the physical block is large, the data will not likely be written to this physical block according to the dynamic wear leveling manner and/or the static wear leveling manner, and the number of times of erasing in the physical block is increased by only 1.

In particular, before modifying the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all physical blocks of the SSD, the method further includes:

1) obtaining the recorded number of times of erasing in the physical block,

2) detecting whether the recorded number of times of erasing in the physical block is less than an average number of times of erasing in all physical blocks in the SSD, and

3) if it is detected that the recorded number of times of erasing in the physical block is less than the average number of times of erasing in all the physical blocks, triggering the step of modifying the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all physical blocks of the SSD.

In the present embodiment, if the number of times of erasing in the physical block is more than the average number of times of erasing in all the physical blocks, the number of times of erasing in the physical block is determined as large; and if the number of times of erasing in the physical block is no more than the average number of times of erasing in all the physical blocks, the number of times of erasing in the physical block is determined as small. Here, the average number of times of erasing in all the physical blocks may be in all the physical blocks availably read. Of course, it is possible to determine whether the number of times of erasing in the physical block is small or large in any other way, which is not limited in the present embodiment.

As can be seen from the above, in the wear leveling method according to the present embodiment, error correction is performed on data read from a physical block to obtain corrected data, and corrected bits in the corrected data are counted to obtain the number of the corrected bits, where the data as read was previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block; it is detected whether the obtained number of the corrected bits is more than the preset bit-number threshold value; and if the number of the corrected bits is determined as more than the preset bit-number threshold value, the data stored in the physical block is transferred, so that the wear leveling of the physical blocks is implemented. Considering the fact that a larger number of corrected bits of data means a shorter residual service life of the physical block containing the data, and that the data is previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, the number of corrected bits may be employed to predict the residual service life of the physical block, and data stored in a physical block with a short residual service life is transferred to another physical block that has been erased for a relatively small number of times and has a longer residual service life, so that the case where a physical block erased for a small number of times that is selected for storing data might be provided with a small allowable number of times of erasing is avoided, and the security of data written to the physical block is improved. In addition, the number of times of erasing in the physical block is modified as the maximal one among the current numbers of times of erasing in all physical blocks of the SSD instead of being increased by 1, so that the data will not be written to this physical block according to the dynamic wear leveling manner and/or the static wear leveling manner, thereby preventing the increase of the number of times of erasing in this physical block and further prolonging the residual service life of the SSD.

Figure 3 is a structural block diagram showing a wear leveling apparatus according to an embodiment of the present invention. The wear leveling apparatus may be applied to an FTL and includes:

a first obtaining module 310, which is configured to perform error correction on data read from a physical block to obtain corrected data, and count corrected bits in the corrected data to obtain the number of the corrected bits, where the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block;

a first detecting module 320, which is configured to detect whether the obtained number of the corrected bits is more than a preset bit-number threshold value; and

a transferring module 330, which is configured to transfer the data stored in the physical block, if the first detecting module 320 detects that the number of the corrected bits is more than the preset bit-number threshold value.

As can be seen from the above, in the wear leveling method according to the present embodiment, error correction is performed on data read from a physical block to obtain corrected data, and corrected bits in the corrected data are counted to obtain the number of the corrected bits, where the data as read was previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block; it is determined whether the obtained number of the corrected bits is more than the preset bit-number threshold value; and if the number of the corrected bits is determined as more than the preset bit-number threshold value, the data stored in the physical block is transferred, so that the wear leveling of the physical blocks is implemented. Considering the fact that a larger number of corrected bits of data means a shorter residual service life of the physical block containing the data, and that the data is previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, the number of corrected bits may be employed to predict the residual service life of the physical block, and data stored in a physical block with a short residual service life is transferred to another physical block that has been erased for a relatively small number of times and has a longer residual service life, so that the case where a physical block erased for a small number of times that is selected for storing data might be provided with a small allowable number of times of erasing is avoided, and the security of data written to the physical block is improved.

Figure 4 is a structural block diagram showing a wear leveling apparatus according to another embodiment of the present invention. The present embodiment is different from the preceding embodiment in that additional modules are included, and these additional modules are configured to write data to a physical block of an SSD in the dynamic wear leveling manner and/or the static wear leveling manner, and after the data in the physical block is transferred, erase the data stored in the physical block and modify the number of times of erasing in the physical block, so that the number of times of erasing in each physical block of the SSD may be made more even with that in the other physical blocks of the SSD, and the service life of the SSD is further prolonged. The wear leveling apparatus includes the first obtaining module 310, the first detecting module 320 and the transferring module 330.

The first obtaining module 310 is configured to perform error correction on data read from a physical block to obtain corrected data, and count corrected bits in the corrected data to obtain the number of the corrected bits, where the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block.

The first detecting module 320 is configured to detect whether the obtained number of the corrected bits is more than a preset bit-number threshold value.

The transferring module 330 is configured to transfer the data stored in the physical block, if the first detecting module 320 detects that the number of the corrected bits is more than the preset bit-number threshold value.

The wear leveling apparatus further includes:

an erasing module 340, which is configured to erase the data stored in the physical block after the data is transferred from the physical block by the transferring module 330; and

a modifying module 350, which is configured to, after the data stored in the physical block is erased by the erasing module 340, modify the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all physical blocks of the SSD.

Further, the wear leveling apparatus may further include:

a second obtaining module 360, which is configured to obtain the recorded number of times of erasing in the physical block before the modifying module 350 modifies the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all physical blocks of the SSD;

a second detecting module 370, which is configured to detect whether the recorded number of times of erasing in the physical block that is obtained by the second obtaining module 360 is less than the average number of times of erasing in all physical blocks in the SSD; and

a triggering module 380, which is configured to, if the second detecting module 370 detects that the obtained recorded number of times of erasing in the physical block is less than the average number of times of erasing in all the physical blocks, trigger the modifying module 350 to modify the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all physical blocks of the SSD.

Further, the wear leveling apparatus includes:

a third detecting module 390, which is configured to detect whether the update period of the data is longer than the preset period threshold value before the first obtaining module 310 performs the error correction on the data read from the physical block to obtain corrected data and counts corrected bits in the corrected data to obtain the number of the corrected bits; and

a writing module 400, which is configured to write the data to a free physical block that has been erased for the most times if the third detecting module 390 detects that the update period of the data is longer than the preset period threshold value.

Particularly, the third detecting module 390 includes:

an obtaining unit 391, which is configured to obtain the type of data;

a detecting unit 392, which is configured to detect whether the type of the data that is obtained by the obtaining unit 391 is one from a preset data type list; and

a determining unit 393, which is configured to determine that the update period of the data is longer than the preset period threshold value if the detecting unit 392 detects that the type of the data is one from the preset data type list.

As can be seen from the above, in the wear leveling method according to the present embodiment, error correction is performed on data read from a physical block to obtain corrected data, and corrected bits in the corrected data are counted to obtain the number of the corrected bits, where the data as read was previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block; it is determined whether the obtained number of the corrected bits is more than the preset bit-number threshold value; and if the number of the corrected bits is determined as more than the preset bit-number threshold value, the data stored in the physical block is transferred, so that the wear leveling of the physical blocks is implemented. Considering the fact that a larger number of corrected bits of data means a shorter residual service life of the physical block containing the data, and that the data is previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, the number of corrected bits may be employed to predict the residual service life of the physical block, and data stored in a physical block with a short residual service life is transferred to another physical block that has been erased for a relatively small number of times and has a longer residual service life, so that the case where a physical block erased for a small number of times that is selected for storing data might be provided with a small allowable number of times of erasing is avoided, and the security of data written to the physical block is improved. In addition, the number of times of erasing in the physical block is modified as the current maximal number of times of erasing among all physical blocks in the SSD instead of being increased by 1, so that the data will not be written to this physical block according to the dynamic wear leveling manner and/or the static wear leveling manner, thereby preventing the increase of the number of times of erasing in this physical block and further prolonging the residual service life of the SSD.

It is noted that the wear leveling apparatus provided in the above embodiment implements the wear leveling by its various functional modules as described in the above example. However, the functions of the various modules may be alternatively achieved by different functional modules in practice, that is, the internal structure of the wear leveling apparatus may be divided into different functional modules to achieve all or a part of the above functions. In addition, the wear leveling apparatus shares the same concept with the wear leveling method provided as above, and reference may be made to the description of the wear leveling method for details of the implementation of the wear leveling apparatus, which will not be described again in detail herein.

It will be appreciated by those skilled in the art that all or a part of the above steps in the embodiments may be accomplished by hardware, or accomplished by hardware instructed by a software program. The software program may be stored in a computer-readable storage medium, which may be a Read Only Memory, a disk or a Compact Disk, for example.

Additionally, an embodiment of the present invention provides a storage medium containing computer-readable instructions, where the computer-readable instructions, when being executed by a computer processor, are configured to perform a wear leveling method including steps of:

performing error correction on data read from a physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, where the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block;

detecting whether the obtained number of the corrected bits is more than a preset bit-number threshold value; and

transferring the data stored in the physical block, if the number of the corrected bits is detected as more than the preset bit-number threshold value.

The wear leveling method performed by the computer-readable instructions being executed by the computer processor is not limited to the above steps. That is, the computer-readable instructions being executed by the computer processor may be configured to perform any other step of the wear leveling method provided in any embodiment of the invention.

The exemplary embodiments of the present invention have been described as above, but are not intended to limit the invention. Modifications, substitutions and improvements to the present invention may readily occur to those skilled in the art in light of the principle of the embodiments of the present invention without departing from the scope of the invention, and all these modifications, substitutions and improvements fall within the scope of the invention.

CLAIMS

1. A wear leveling method, comprising:

performing error correction on data read from a physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, wherein the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with a residual service life of the physical block;

detecting whether the obtained number of the corrected bits is more than a preset bit-number threshold value; and

transferring data stored in the physical block, if the number of the corrected bits is detected as more than the preset bit-number threshold value.

2. The wear leveling method of claim 1, wherein after transferring data stored in the physical block, the method further comprises:

erasing the data stored in the physical block; and

modifying the number of times of erasing in the physical block as the maximal one among current numbers of times of erasing in all physical blocks.

3. The wear leveling method of claim 2, wherein before modifying the number of times of erasing in the physical block as the maximal one among current numbers of times of erasing in all physical blocks, the method further comprises:

obtaining a recorded number of times of erasing in the physical block,

detecting whether the recorded number of times of erasing in the physical block is less than an average number of times of erasing in all the physical blocks, and

if it is detected that the recorded number of times of erasing in the physical block is less than the average number of times of erasing in all the physical blocks, triggering modifying of the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all the physical blocks.

4. The wear leveling method of any one of claims 1 to 3, wherein before performing error correction on data read from the physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, the method further comprises:

detecting whether an update period of the data is longer than a preset period threshold value; and

writing the data to a free physical block that has been erased for the most times if the update period of the data is detected as longer than the preset period threshold value.

5. The wear leveling method of claim 4, wherein the detecting whether the update period of the data is longer than the preset period threshold value comprises:

obtaining the type of the data;

detecting whether the type of the data is one from a preset data type list; and

determining that the update period of the data is longer than the preset period threshold value if the type of the data is detected as one from the preset data type list.

6. A wear leveling apparatus, comprising:

a first obtaining module, which is configured to perform error correction on data read from a physical block to obtain corrected data, and count corrected bits in the corrected data to obtain the number of the corrected bits, wherein the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with a residual service life of the physical block;

a first detecting module, which is configured to detect whether the obtained number of corrected bits is more than a preset bit-number threshold value; and

a transferring module, which is configured to transfer data stored in the physical block, if the number of corrected bits is detected as more than the preset bit-number threshold value.

7. The wear leveling apparatus of claim 6, further comprising:

an erasing module, which is configured to erase the data stored in the physical block after the data is transferred from the physical block by the transferring module; and

a modifying module, which is configured to, after the data in the physical block is erased by the erasing module, modify the number of times of erasing in the physical block as the maximal one among current numbers of times of erasing in all physical blocks.

8. The wear leveling apparatus of claim 7, further comprising:

a second obtaining module, which is configured to obtain a recorded number of times of erasing in the physical block before the modifying module modifies the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all the physical blocks;

a second detecting module, which is configured to detect whether the recorded number of times of erasing in the physical block that is obtained by the second obtaining module is less than an average number of times of erasing in all the physical blocks; and

a triggering module, which is configured to, if the second detecting module detects that the obtained recorded number of times of erasing in the physical block is less than the average number of times of erasing in all the physical blocks, trigger the modifying module to modify the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all the physical blocks.

9. The wear leveling apparatus of any one of claims 6 to 8, further comprising:

a third detecting module, which is configured to detect whether an update period of the data is longer than a preset period threshold value before the first obtaining module performs the error correction on the data read from the physical block to obtain corrected data and counts corrected bits in the corrected data to obtain the number of the corrected bits; and

a writing module, which is configured to write the data to a free physical block that has been erased for the most times if the third detecting module detects that the update period of the data is longer than the preset period threshold value.

10. The wear leveling apparatus of claim 9, further comprising:

an obtaining unit, which is configured to obtain the type of the data;

a detecting unit, which is configured to detect whether the type of the data that is obtained by the obtaining unit is one from a preset data type list; and

a determining unit, which is configured to determine that the update period of the data is longer than the preset period threshold value if the detecting unit detects that the type of the data is one from the preset data type list.

11. A storage medium containing computer-readable instructions, wherein the computer-readable instructions, when being executed by a computer processor, are configured to perform a wear leveling method comprising steps of:

performing error correction on data read from a physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, wherein the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block;

detecting whether the obtained number of corrected bits is more than a preset bit-number threshold value; and

transferring data stored in the physical block, if the number of corrected bits is detected as more than the preset bit-number threshold value.

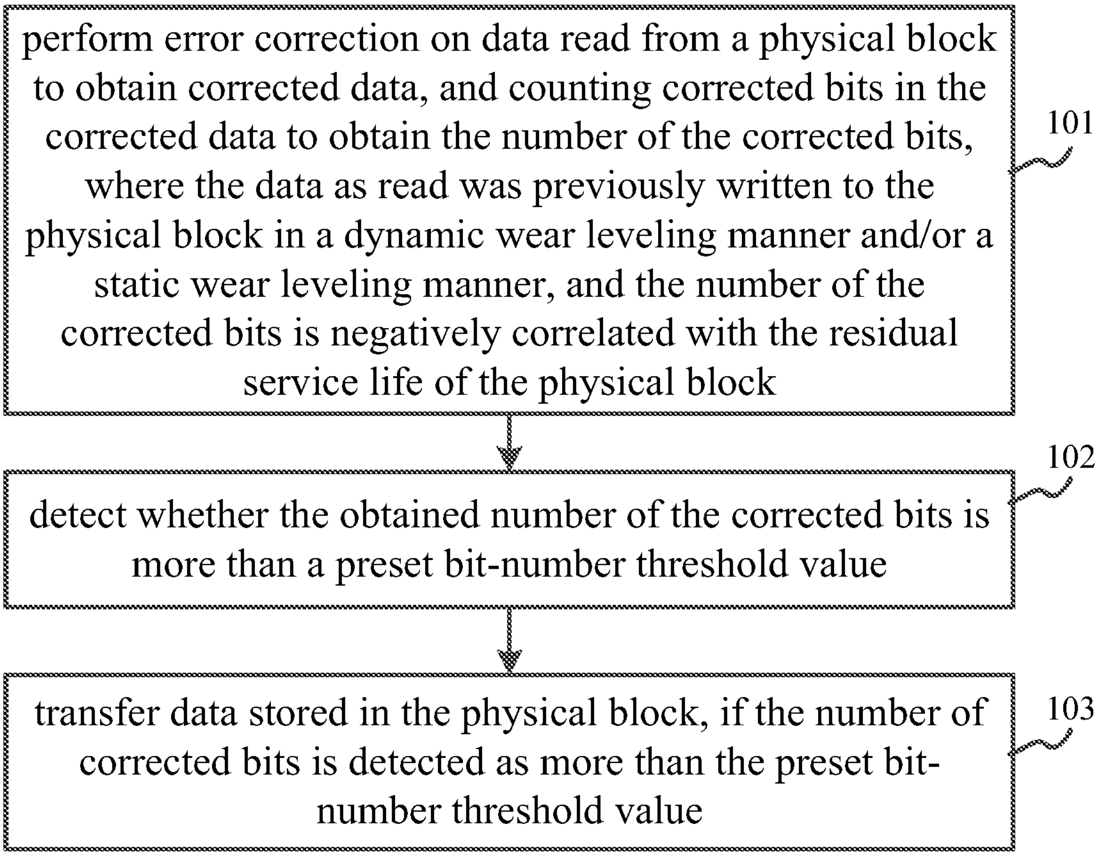
perform error correction on data read from a physical block to obtain corrected data, and counting corrected bits in the corrected data to obtain the number of the corrected bits, where the data as read was previously written to the physical block in a dynamic wear leveling manner and/or a static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block
101
detect whether the obtained number of the corrected bits is more than a preset bit-number threshold value
102
transfer data stored in the physical block, if the number of corrected bits is detected as more than the preset bit-number threshold value
103

FIGURE 1

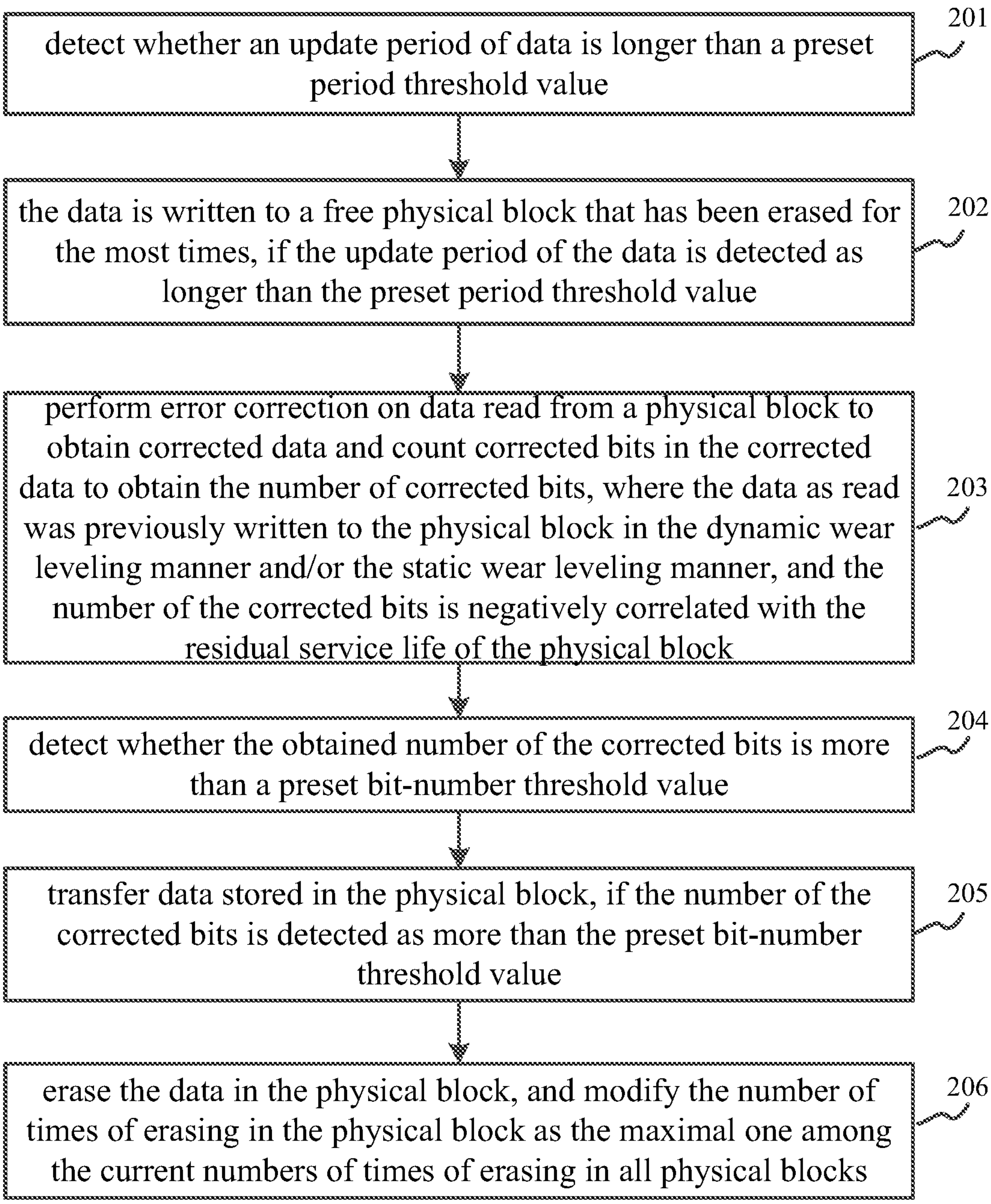
detect whether an update period of data is longer than a preset period threshold value
201
the data is written to a free physical block that has been erased for the most times, if the update period of the data is detected as longer than the preset period threshold value
202
perform error correction on data read from a physical block to obtain corrected data and count corrected bits in the corrected data to obtain the number of corrected bits, where the data as read was previously written to the physical block in the dynamic wear leveling manner and/or the static wear leveling manner, and the number of the corrected bits is negatively correlated with the residual service life of the physical block
203
detect whether the obtained number of the corrected bits is more than a preset bit-number threshold value
204
transfer data stored in the physical block, if the number of the corrected bits is detected as more than the preset bit-number threshold value
205
erase the data in the physical block, and modify the number of times of erasing in the physical block as the maximal one among the current numbers of times of erasing in all physical blocks
206

FIGURE 2

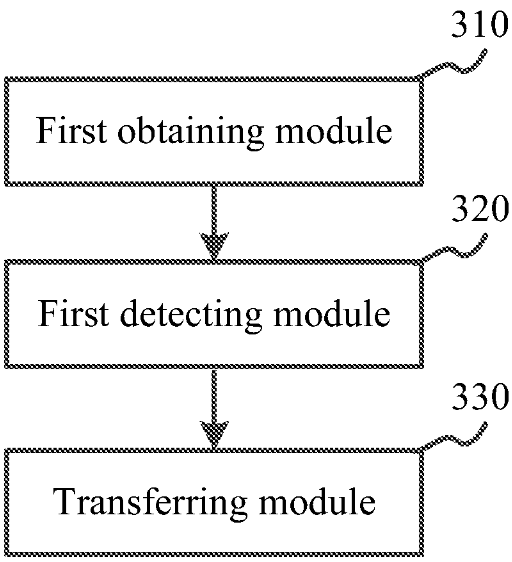
310
First obtaining module
320
First detecting module
330
Transferring module

FIGURE 3

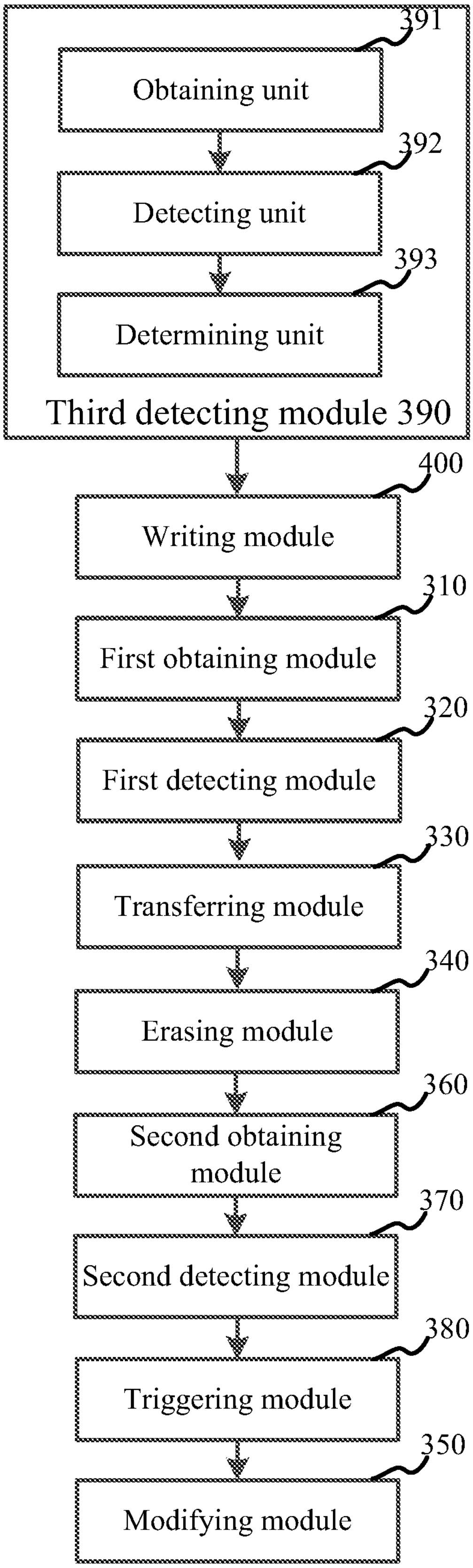
391
Obtaining unit
392
Detecting unit
393
Determining unit
Third detecting module 390
400
Writing module
310
First obtaining module
320
First detecting module
330
Transferring module
340
Erasing module
360
Second obtaining module
370
Second detecting module
380
Triggering module
350
Modifying module

FIGURE 4

INTERNATIONAL SEARCH REPORT	International application No. PCT/CN2014/088755

A. CLASSIFICATION OF SUBJECT MATTER

G06F 12/06(2006.01)i; G06F 3/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, CNPAT, CNKI: wear, leveling, error, correct+, physical, block, number, bit, preset, threshold

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103092770 A (SHANDONG SINOCHIP SEMICONDUCTORS CO., LTD.) 08 May 2013 (2013-05-08) abstract, claims 1-9	1-11
A	CN 102789813 A (SHENZHEN NETCOM ELECTRONICS CO., LTD.) 21 November 2012 (2012-11-21) the whole document	1-11
A	CN 102789423 A (SHANDONG SINOCHIP SEMICONDUCTORS CO., LTD.) 21 November 2012 (2012-11-21) the whole document	1-11
A	US 2012303868 A1 (TUCEK, JOSEPH A.) 29 November 2012 (2012-11-29) the whole document	1-11

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 December 2014	**21 January 2015**
Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA(ISA/CN) **6,Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088 China**	**ZHANG,Tao**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)62414427**

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/088755

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	103092770	A	08 May 2013		Non	e	
CN	102789813	A	21 November 2012	WO	2013189212	A1	27 December 2013
CN	102789423	A	21 November 2012		Non	e	
US	2012303868	A1	29 November 2012	WO	2011099963	A1	18 August 2011