

DATA PROCESSING METHOD AND APPARATUS, AND FLASH DEVICE

TECHNICAL FIELD

[0001] The present invention relates to the field of flash device technologies, and
5 specifically, to a data processing method and apparatus, and a flash device.

BACKGROUND

[0002] A solid state disk (also called Solid State Drive), referred to as SSD for short, is a
hard disk made of a solid-state electronic storage chip array. The SSD is widely applied to
fields such as military, vehicles, industrial control, video surveillance, network monitoring,
10 network terminals, electricity, medical care, aviation, and navigation devices. On the market,
common SSD capacities usually include 60/64 GB, 120/128 GB, 240/256 GB, 480/512 GB,
and 960 /1024 G, where a value on the left of a slash represents a user available space
capacity, a value on the right of a slash represents a physical space capacity of an SSD, and a
difference between the two values is over provisioning (Over Provisioning, OP) space.
15 Usually, a user cannot perform an operation in this part of space, and a capacity of this part of
space is usually determined by a primary controller. OP is generally used for performing an
optimization operation, including wear leveling, garbage collection, bad block mapping, and
the like. An over provisioning ratio is a ratio of an over provisioning space capacity to the
user available space capability, and typical over provisioning ratios in the industry are 7% and
20 28%. A physical space capacity of 1024 GB is used as an example. When a user available
space capacity is 960 GB, a corresponding over provisioning ratio is 7%, that is,
(1024–960)/960. When a user available space capacity is 800 GB, a corresponding over
provisioning ratio is 28%, that is, (1024–800)/800. A larger over provisioning ratio indicates
better random write performance, smaller performance fluctuation, and a longer service life,

but higher costs.

[0003] A flash memory in the SSD needs to be erased before being rewritten, and is written and read in pages while being erased in blocks. Therefore, a volume of actually written data is much greater than that of data written by using a host. Write amplification (Write Amplification, WA) is a ratio of a volume of actually written data to a size of data written by using a host. Larger WA indicates a smaller over provisioning ratio, a shorter service life, and poorer random write performance.

[0004] Currently, an SSD vendor provides multiple over provisioning ratios for an SSD of a specific capacity, and a user selects a fixed over provisioning ratio according to a user requirement. Once an over provisioning ratio is fixed, parameters of the SSD are fixed, and performance and a service life of the SSD are also fixed. In this way, the SSD can only run at the fixed over provisioning ratio. Consequently, it is difficult to further optimize the performance and the service life of the SSD.

SUMMARY

[0005] Embodiments of the present invention provide a data processing method and apparatus, and a flash device, so as to dynamically adjust an over provisioning ratio, improve reliability and performance stability of a flash device, and prolong a service life of the flash device.

[0006] A first aspect of the embodiments of the present invention provides a data processing method, where the method is applied to a storage system, and the storage system includes a host and a flash device, where multiple over provisioning levels are configured for physical storage space of the flash device according to multiple different over provisioning ratios, each over provisioning level is corresponding to an interval of a user storage space capacity, each interval of the user storage space capacity is corresponding to a different adjustment parameter, the over provisioning ratio is a ratio of an over provisioning space capacity to the user storage space capacity, and the over provisioning space capacity is a difference between a physical storage space capacity and the user storage space capacity; and the method is performed by the flash device and includes:

receiving an operation instruction sent by the host, performing, according to the operation instruction, an operation on data stored in the flash device, and determining a size of data that is obtained after the operation and that is saved in the flash device by a user;

5 determining a target over provisioning level according to the size of the data that is obtained after the operation and that is saved in the flash device by the user and the interval that is of the user storage space capacity and that is corresponding to each over provisioning level;

10 determining a target adjustment parameter according to the target over provisioning level and a correspondence between each over provisioning level and an adjustment parameter; and

adjusting the over provisioning space capacity of the flash device according to the target adjustment parameter.

[0007] In a first possible implementation of the first aspect of the embodiments of the present invention, the receiving an operation instruction sent by the host, performing,
15 according to the operation instruction, an operation on data stored in the flash device, and determining a size of data that is obtained after the operation and that is saved in the flash device by a user includes:

receiving a write instruction sent by the host, and determining to-be-added data according to the write instruction; and

20 adding the to-be-added data to the flash device, and determining, as the size of the data that is obtained after the operation and that is saved in the flash device by the user, a size of data that is obtained after the to-be-added data is added to the flash device and that is saved by the user.

[0008] In a second possible implementation of the first aspect of the embodiments of the present invention, the receiving an operation instruction sent by the host, performing,
25 according to the operation instruction, an operation on data stored in the flash device, and determining a size of data that is obtained after the operation and that is saved in the flash device by a user includes:

30 receiving a delete instruction sent by the host, and determining to-be-deleted data according to the delete instruction; and

deleting the to-be-deleted data from the flash device, and determining, as the size of the data that is obtained after the operation and that is saved in the flash device by the user, a size of data that is obtained after the to-be-deleted data is deleted and that is saved by the user.

5 **[0009]** With reference to the first possible implementation of the first aspect of the embodiments of the present invention, in a third possible implementation of the first aspect of the embodiments of the present invention, before the adding the to-be-added data to the flash device, the method further includes:

compressing the to-be-added data, where the to-be-added data is compressed data.

10 **[0010]** With reference to any one of the first to the third possible implementations of the first aspect of the embodiments of the present invention, in a fourth possible implementation of the first aspect, after the step of adjusting the over provisioning space capacity of the flash device according to the target adjustment parameter, the method further includes:

performing, according to a target garbage collection adjustment parameter in the
15 target adjustment parameter, garbage collection processing on the data stored in the flash device.

[0011] With reference to any one of the first to the third possible implementations of the first aspect of the embodiments of the present invention, in a fifth possible implementation of the first aspect, after the step of adjusting the over provisioning space capacity of the flash
20 device according to the target adjustment parameter, the method further includes:

performing, according to a target wear leveling adjustment parameter in the target adjustment parameter, wear leveling processing on the data stored in the flash device.

[0012] A second aspect of the embodiments of the present invention provides a data processing apparatus, where the data processing apparatus is applied to a flash device in a
25 storage system, and the storage system further includes a host, where multiple over provisioning levels are configured for physical storage space of the flash device according to multiple different over provisioning ratios, each over provisioning level is corresponding to an interval of a user storage space capacity, each interval of the user storage space capacity is corresponding to a different adjustment parameter, the over provisioning ratio is a ratio of an
30 over provisioning space capacity to the user storage space capacity, and the over provisioning

space capacity is a difference between a physical storage space capacity and the user storage space capacity; and the data processing apparatus includes:

a receiving unit, configured to: receive an operation instruction sent by the host, perform, according to the operation instruction, an operation on data stored in the flash device, and determine a size of data that is obtained after the operation and that is saved in the flash device by a user;

a determining unit, configured to determine a target over provisioning level according to the size of the data that is obtained after the operation and that is saved in the flash device by the user and the interval that is of the user storage space capacity and that is corresponding to each over provisioning level, where

the determining unit is further configured to determine a target adjustment parameter according to the target over provisioning level and a correspondence between each over provisioning level and an adjustment parameter; and

an adjustment unit, configured to adjust the over provisioning space capacity of the flash device according to the target adjustment parameter.

[0013] In a first possible implementation of the second aspect of the embodiments of the present invention, the receiving unit is specifically configured to: receive a write instruction sent by the host, determine to-be-added data according to the write instruction, add the to-be-added data to the flash device, and determine, as the size of the data that is obtained after the operation and that is saved in the flash device by the user, a size of data that is obtained after the to-be-added data is added to the flash device and that is saved by the user.

[0014] In a second possible implementation of the second aspect of the embodiments of the present invention, the receiving unit is specifically configured to: receive a delete instruction sent by the host, determine to-be-deleted data according to the delete instruction, delete the to-be-deleted data from the flash device, and determine, as the size of the data that is obtained after the operation and that is saved in the flash device by the user, a size of data that is obtained after the to-be-deleted data is deleted and that is saved by the user.

[0015] With reference to the first possible implementation of the second aspect of the embodiments of the present invention, in a third possible implementation of the embodiments of the present invention, the receiving unit is further configured to compress the to-be-added

data, and the to-be-added data is compressed data.

[0016] With reference to any one of the first to the third possible implementations of the second aspect of the embodiments of the present invention, in a fourth possible implementation of the embodiments of the present invention, the apparatus further includes:

5 a processing unit, configured to perform, according to a target garbage collection adjustment parameter in the target adjustment parameter, garbage collection processing on the data stored in the flash device.

[0017] With reference to any one of the first to the third possible implementations of the second aspect of the embodiments of the present invention, in a fifth possible implementation
10 of the embodiments of the present invention, the processing unit is further configured to perform, according to a target wear leveling adjustment parameter in the target adjustment parameter, wear leveling processing on the data stored in the flash device.

[0018] A third aspect of the embodiments of the present invention provides a flash device, including the data processing apparatus provided in the second aspect of the embodiments of
15 the present invention.

[0019] In the embodiments of the present invention, an operation instruction sent by a host is received, an operation is performed, according to the operation instruction, on data stored in a flash device, and a size of data that is obtained after the operation and that is saved in the flash device by a user is determined; then, a target over provisioning level is determined
20 according to the size of the data that is obtained after the operation and that is saved in the flash device by the user and an interval that is of a user storage space capacity and that is corresponding to each over provisioning level, and a target adjustment parameter is determined according to the target over provisioning level and a correspondence between each over provisioning level and an adjustment parameter; finally, an over provisioning space
25 capacity of the flash device is adjusted according to the target adjustment parameter. Therefore, an over provisioning ratio of the flash device is dynamically adjusted according to a volume of stored data, and further, reliability and performance stability of the flash device are improved, and a service life of the flash device is prolonged.

BRIEF DESCRIPTION OF DRAWINGS

[0020] To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly describes the accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

[0021] FIG. 1 is a schematic diagram of a network architecture of a storage system in the prior art;

[0022] FIG. 2 is a schematic diagram of over provisioning level configuration according to an embodiment of the present invention;

[0023] FIG. 3 is a schematic structural diagram of a flash device according to an embodiment of the present invention;

[0024] FIG. 4 is a schematic flowchart of a data processing method according to an embodiment of the present invention;

[0025] FIG. 5 is a schematic flowchart of another data processing method according to an embodiment of the present invention; and

[0026] FIG. 6 is a schematic structural diagram of a data processing apparatus according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0027] The following clearly and completely describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely some but not all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0028] For better understanding of a data processing method and apparatus, and a flash device that are disclosed in the embodiments of the present invention, the following first

describes a network architecture of a storage system in the prior art. Referring to FIG. 1, FIG. 1 is a schematic diagram of a network architecture of a storage system in the prior art. The storage system shown in FIG. 1 includes a host and a flash device. It should be noted that, the storage system in the prior art includes multiple hosts and multiple flash devices, and one host and one flash device in the storage system are described in the embodiments of the present invention. The host may include but is not limited to a device such as a desktop computer, a notebook computer, or a server, and the host controls the flash device by sending a series of instructions. The flash device performs a corresponding operation such as reading, writing, or deleting according to an instruction sent by the host. Physical storage space of the flash device includes over provisioning space and user storage space, the physical storage space is total space of the flash device, and the user storage space is used to store data input by a user by using the host. The data processing method and apparatus, and the flash device that are provided in the embodiments of the present invention may be applied to the storage system shown in FIG. 1, and may be specifically applied to a scenario of adjusting over provisioning space of a flash device. The data processing apparatus in the embodiments of the present invention is located in the flash device.

[0029] The flash device in the embodiments of the present invention may include but is not limited to a storage device with a NAND flash (NAND Flash), for example, a solid state drive (Solid State Disk, SSD), a removable hard disk, a floppy disk, a USB flash drive, or an SD card. It should be noted that a solid state drive in the flash memory is mainly described in the embodiments of the present invention, and another flash device may also be used in the embodiments of the present invention.

[0030] The solid state drive SSD mainly includes a primary controller and a NAND flash. The NAND flash is a non-volatile random access storage medium and is characterized by losing no data after the NAND flash is powered off. The NAND flash is different from a conventional volatile random access storage medium and a conventional volatile flash device such as a dynamic random access memory DRAM and a static random access memory SRAM, and therefore, may be used as an external flash device. The NAND flash is classified into two types: a single level cell (Single Level Cell, SLC) and a multi-level cell (Multi-Level Cell, MLC), and a main difference between the two is that they have different structures. At

present, most NAND flashes on the market use an MLC chip.

[0031] A NAND flash component generally includes an internal register and a storage matrix. The storage matrix includes several blocks, each block contains several pages, and each page contains several bytes. Main operations performed on the NAND flash are reading, writing, and erasing. Because the flash device is a non-volatile semiconductor, the NAND flash is read and written in pages and is erased in blocks. A page needs to be erased before being written. A sequence of using the NAND flash is usually: erase → program → read for multiple times → erase...

[0032] Over provisioning (Over Provisioning, OP) space is space in which a user cannot perform an operation and whose size is a physical space capacity of an SSD minus a user available space capacity. An OP area is usually used for an optimization operation, for example, wear leveling, garbage collection, and bad block mapping.

[0033] Wear leveling (Wear leveling, WL) is a mechanism used to ensure that quantities of times for which all blocks are written are equal. Data in user logical address space is updated at different speeds. Data in some areas is frequently updated, but data in some areas is not frequently updated. Apparently, a flash block occupied by the data that is frequently updated is quickly worn out, while a flash block occupied by the data that is not frequently updated is less worn out. This problem can be well resolved by using the wear leveling mechanism, so that quantities of times for which all flash blocks are programmed are kept to be the same as much as possible.

[0034] Garbage collection (Garbage Collection, GC) means copying data on a valid page of a flash block to a blank block and then erasing the entire block. GC is an extremely crucial operation for an SSD, and GC efficiency has decisive impact on performance. A quantity of valid pages of the flash block has decisive impact on the GC efficiency, that is, a smaller quantity of valid pages indicates a smaller quantity of pages that need to be copied and indicates that a less time is cost, so as to improve the garbage collection efficiency.

[0035] Write amplification (Write amplification, WA) is a ratio of a size of data actually written into a NAND flash to a size of data written by using a host. Because the NAND flash needs to be erased before being written, during execution of these operations, user data is moved or overwritten more than once. These repeated operations not only increase a volume

of written data and shorten a service life of an SSD, but also consume bandwidth of the NAND flash and indirectly affect random write performance of the SSD. For example, when data of 4 KB needs to be written, in a worst case in which a block has no clean space but has invalid data that can be erased, a primary controller reads all data to a cache and erases the block, data of the entire block is updated in the cache, and new data is written back. Write amplification resulting from this operation is: Actually writing data of 4 KB causes a write operation on the entire block (1024 KB in total), that is, a volume of written data is amplified by 256 times. At the same time, a simple one-step operation of writing the data of 4 KB becomes a four-step operation: Read from a flash memory (1024 KB) → Update in a cache (4 KB) → Erase the flash memory (1024 KB) → Write into the flash memory (1024 KB). Consequently, a delay is greatly increased, and a write speed is decreased. Therefore, write amplification is a key factor that affects the random write performance and the service life of the SSD.

[0036] Multiple over provisioning levels are configured for the physical storage space of the flash device in the embodiments of the present invention according to multiple different over provisioning ratios. For details, refer to a schematic diagram of over provisioning level configuration shown in FIG. 2. It should be noted that, a value in FIG. 2 is only an example, and a specific value may be set by a manufacturer of a flash device and is not limited herein. A flash device whose physical storage space capacity is 1024 G is used as an example in FIG. 2. If an over provisioning ratio is 7%, a user storage space capacity is 960 G, and a difference 64 G between 1024 G and 960 G is an over provisioning space capacity of the flash device. In the embodiments of the present invention, five over provisioning levels: a level 0, a level 1, a level 2, a level 3, a level 4, and a level 5 are configured for physical storage space 1024 G of the flash device according to multiple different over provisioning ratios, and corresponding intervals of the user storage space capacity are respectively (800 G, 960 G], (720 G, 800 G], (660 G, 720 G], (520 G, 660 G], (400 G, 520 G], and [0 G, 400 G]. In the embodiments of the present invention, a corresponding adjustment parameter is further configured for each user storage space capacity. The adjustment parameter includes parameters such as an over provisioning space adjustment parameter, a garbage collection GC adjustment parameter, a wear leveling WL adjustment parameter, write amplification WA, and hot and cold data

exchange frequency. Because each over provisioning level is corresponding to an interval of the user storage space capacity, and each interval of the user storage space capacity is corresponding to a different adjustment parameter, a correspondence between each over provisioning level and an adjustment parameter can be derived. In the prior art, when manufacturing an SSD flash device, a manufacturer of the flash device usually provides a fixed over provisioning ratio for a customer according to a customer requirement. Once an over provisioning ratio is fixed, it is difficult to further optimize performance, parameters, a service life, and the like of the SSD flash device.

[0037] Based on the network architecture shown in FIG. 1, referring to FIG. 3, FIG. 3 is a schematic structural diagram of a flash device according to an embodiment of the present invention. As shown in FIG. 3, the flash device includes at least one processor 1001 such as a CPU, a communications interface 1003, a memory 1004, and at least one communications bus 1002. Optionally, the processor 1001 is a primary controller of the flash device. The communications interface 1003 is configured to receive an operation instruction sent by a host that is in a same storage system as the flash device. The communications bus 1002 is configured to implement connections and communication between these elements. The memory 1005 may be a NAND flash memory configured to store data. Multiple over provisioning levels are configured for physical storage space of the memory 1005 according to multiple different over provisioning ratios, each over provisioning level is corresponding to an interval of a user storage space capacity, each interval of the user storage space capacity is corresponding to a different adjustment parameter, the over provisioning ratio is a ratio of an over provisioning space capacity to the user storage space capacity, and the over provisioning space capacity is a difference between a physical storage space capacity and the user storage space capacity.

[0038] In the following, data processing methods according to the embodiments of the present invention are described in detail with reference to FIG. 3 to FIG. 5.

[0039] Referring to FIG. 4, FIG. 4 is a schematic flowchart of a data processing method according to an embodiment of the present invention. With reference to the flash device described in FIG. 3, the memory 1005 stores a group of program code, and the processor 1001 invokes the program code stored in the memory 1005 to perform the data processing method.

The method may include the following step S101 to step S104.

[0040] S101. Receive an operation instruction sent by a host, perform, according to the operation instruction, an operation on data stored in a flash device, and determine a size of data that is obtained after the operation and that is saved in the flash device by a user.

5 **[0041]** Optionally, the processor 1001 performs, according to the operation instruction that is sent by the host and that is received by the communications interface 1003, an operation on data stored in the memory 1005, and determines a size of data that is obtained after the operation and that is saved in the memory 1005 by the user. When the communications interface 1003 receives the operation instruction, the processor 1001 first
10 determines whether the operation instruction has been executed. If a result of the determining is no, that is, the processor 1001 has not executed the operation instruction, the operation is performed on the data stored in the memory 1005. Before the processor 1001 performs the operation, the memory 1005 may store a part of data, and this part of data is used as an initial size of data in the flash device. The initial size of data may change after the operation is
15 performed. Therefore, the flash device needs to determine the size of the data that is obtained after the operation and that is saved in the memory 1005 by the user, and determines, according to the size of the data that is obtained after the operation and that is saved in the memory 1005 by the user, whether an over provisioning level for the flash device needs to be adjusted. If the processor 1001 has executed the operation instruction, it may be understood
20 that the processor 1001 has performed, according to the operation instruction, the operation on the data stored in the memory 1005. In this case, no processing is performed on the flash device.

[0042] The operation instruction includes a write instruction or a delete instruction. Specifically, when the operation instruction is the write instruction, the processor 1001 first
25 determines whether the write instruction has been executed, and if no, determines to-be-added data, adds the to-be-added data to the flash device to increase the initial size of data on an original basis, and therefore, determines, as the size of the data that is obtained after the operation and that is saved in the memory 1005 by the user, a sum of the initial size of data and a volume of the to-be-added data. When the operation instruction is the delete instruction,
30 the processor 1001 first determines whether the delete instruction has been executed, and if

no, determines to-be-deleted data, deletes the to-be-deleted data from the memory 1005 to decrease the initial size of data on an original basis, and therefore, determines, as the size of the data that is obtained after the operation and that is saved in the memory 1005 by the user, a difference between the initial size of data and a volume of the to-be-deleted data.

5 **[0043]** S102. Determine a target over provisioning level according to the size of the data that is obtained after the operation and that is saved in the flash device by the user and an interval that is of a user storage space capacity and that is corresponding to each over provisioning level.

10 **[0044]** Optionally, because multiple over provisioning levels are configured for the flash device according to different over provisioning ratios, and each over provisioning level is corresponding to an interval of the user storage space capacity, the processor 1001 determines the target over provisioning level according to the size of the data that is obtained after the operation and that is saved in the memory 1005 by the user and the interval that is of the user storage space capacity and that is corresponding to each over provisioning level. If the size of
15 the data that is obtained after the operation and that is saved in the memory 1005 by the user is 500 G, it can be learned from FIG. 2 that, in this case, a corresponding interval of the user storage space capacity is (400 G, 520 G], a corresponding over provisioning level is a level 4, and the level 4 is determined as the target over provisioning level. If the flash device has not been used or formatted, the target over provisioning level is set to a level 5 by default.

20 **[0045]** S103. Determine a target adjustment parameter according to the target over provisioning level and a correspondence between each over provisioning level and an adjustment parameter.

25 **[0046]** Optionally, because multiple over provisioning levels are configured for the flash device according to different over provisioning ratios, each over provisioning level is corresponding to an interval of the user storage space capacity, and each interval of the user storage space capacity is corresponding to a different adjustment parameter, the correspondence between each over provisioning level and an adjustment parameter can be derived, that is, the flash device configures different adjustment parameters for over provisioning levels. The processor 1001 determines the target adjustment parameter according
30 to the target over provisioning level and the correspondence between each over provisioning

level and an adjustment parameter. The target adjustment parameter may be the same as or different from an adjustment parameter used before the operation instruction is received, and is determined according to the size of the data that is obtained after the operation and that is saved in the memory 1005 by the user. If the size of the data that is obtained after the operation and that is saved in the memory 1005 by the user and the initial size of data belong to a same interval of the user storage space capacity, the target adjustment parameter is the same as an adjustment parameter corresponding to the initial size of data; otherwise, the target adjustment parameter is different from an adjustment parameter corresponding to the initial size of data. Each time a size of the data saved in the memory 1005 by the user changes, the processor 1001 needs to determine a new target over provisioning level and a new target adjustment parameter. In the prior art, because there is a fixed over provisioning ratio and a fixed over provisioning space capacity, regardless of a change in the size of the data saved in the memory 1005 by the user, the processor 1001 adjusts, according to a fixed adjustment parameter, the data saved by the user. In this way, reliability and performance stability of the flash device are affected to some extent.

[0047] S104. Adjust an over provisioning space capacity of the flash device according to the target adjustment parameter.

[0048] Optionally, the processor 1001 adjusts an over provisioning space capacity of the memory 1005 according to the target adjustment parameter. In the prior art, an over provisioning space capacity of each flash device has been determined at delivery, so that processing performance of the flash device is limited to some extent. Over provisioning space of the memory 1005 in this embodiment of the present invention is not fixed, but varies with the size of the data saved in the memory 1005 by the user, and the over provisioning space capacity of the memory 1005 is correspondingly adjusted according to an adjustment parameter, so that the flash device is in an optimal running state. For example, the target adjustment parameter is an adjustment parameter corresponding to a level 4, and corresponding over provisioning space in this case is adjusted to 1024 G–520 G=504 G according to the target adjustment parameter. Compared with corresponding over provisioning space 64 G of a flash device whose fixed over provisioning ratio is 7% in the prior art, the over provisioning space is increased, and this helps to reduce WA. Therefore, compared with

that in the prior art, the flash device in this embodiment of the present invention has higher reliability and higher performance stability.

[0049] The target adjustment parameter includes a target garbage collection adjustment parameter and a target wear leveling adjustment parameter. After adjusting the over provisioning space capacity of the memory 1005, the processor 1001 performs, according to the target garbage collection adjustment parameter, garbage collection processing on the data stored in the flash device, and performs, according to the target wear leveling adjustment parameter, wear leveling adjustment processing on the data stored in the flash device.

[0050] It should be noted that, over provisioning space in the prior art is fixed and is not accessible to a user, but the over provisioning space in this embodiment of the present invention may be changed dynamically. A specific over provisioning level is corresponding to fixed over provisioning space, but the over provisioning space changes when the over provisioning level is changed to another level.

[0051] In this embodiment of the present invention, an operation instruction sent by a host is received, an operation is performed, according to the operation instruction, on data stored in a flash device, and a size of data that is obtained after the operation and that is saved in the flash device by a user is determined; then, a target over provisioning level is determined according to the size of the data that is obtained after the operation and that is saved in the flash device by the user and an interval that is of a user storage space capacity and that is corresponding to each over provisioning level, and a target adjustment parameter is determined according to the target over provisioning level and a correspondence between each over provisioning level and an adjustment parameter; finally, an over provisioning space capacity of the flash device is adjusted according to the target adjustment parameter. Therefore, an over provisioning ratio of the flash device is dynamically adjusted according to a volume of stored data, and further, reliability and performance stability of the flash device are improved, and a service life of the flash device is prolonged.

[0052] Referring to FIG. 5, FIG. 5 is a schematic flowchart of another data processing method according to an embodiment of the present invention. With reference to the flash device described in FIG. 3, the memory 1005 stores a group of program code, and the processor 1001 invokes the program code stored in the memory 1005 to perform the data

processing method. The method may include the following step S201 to step S210.

[0053] S201. Receive a write instruction sent by a host, and determine to-be-added data according to the write instruction.

[0054] Optionally, the communications interface 1003 receives the write instruction sent
5 by the host, and transmits the write instruction to the processor 1001 by using the communications bus 1002. The processor 1001 determines the to-be-added data according to the write instruction. When receiving the write instruction, the processor 1001 determines whether the write instruction has been executed. The host and the flash device are in a storage system, and the host controls running of the flash device, and may include but is not limited to
10 a device such as a desktop computer, a notebook computer, or a server. Because the write instruction received by the processor 1001 may have been executed, the processor 1001 needs to determine whether the write instruction has been executed. If the write instruction has not been executed, it may be understood that the processor 1001 has not added data to the memory 1005 according to the write instruction. If the write instruction has been executed, it
15 may be understood that the processor 1001 has added data to the memory 1005 according to the write instruction. If the write instruction is received again, a size of data stored in the memory 1005 does not change. In this case, no processing is performed on the flash device. Determining the to-be-added data includes determining content and a volume of the to-be-added data.

20 **[0055]** S202. Compress the to-be-added data.

[0056] Optionally, the processor 1001 compresses the to-be-added data. Some SSDs have a compression function, so that a size of data that is actually added by a user to an SSD is a size of data obtained after the added data is compressed. Therefore, the to-be-added data is compressed compressed data.

25 **[0057]** It should be noted that, step S202 in this embodiment of the present invention is performed when an SSD has a compression function, and if the SSD does not have the compression function, step S202 is not performed, and step S203 is directly performed.

[0058] S203. Add the to-be-added data to a flash device, and determine, as a size of data that is obtained after an operation and that is saved in the flash device by a user, a size of data
30 that is obtained after the to-be-added data is added to the flash device and that is saved by the

user.

[0059] Optionally, the processor 1001 adds the to-be-added data to the memory 1005, so as to add a new size of data to a size of data previously saved in the memory 1005 by the user; and determines, as a size of data that is obtained after an operation and that is saved in the memory 1005 by the user, a size of data that is obtained after the to-be-added data is added to the memory 1005 and that is saved by the user.

[0060] S204. Receive a delete instruction sent by a host, and determine to-be-deleted data according to the delete instruction.

[0061] Optionally, the processor 1001 receives the delete instruction sent by the host, and transmits the delete instruction to the processor 1001 by using the communications bus 1002.

The processor 1001 determines the to-be-deleted data according to the delete instruction.

When receiving the delete instruction, the processor 1001 determines whether the delete instruction has been executed. The delete instruction is a trim (TRIM) instruction. A prerequisite for implementing this embodiment of the present invention is that the flash device can support the trim instruction. The trim instruction is used by an operating system to inform, after a file is deleted or formatting is performed, a primary controller of an SSD that this data block is no longer needed. When some files are deleted or an entire partition is formatted, the operating system sends, to the primary controller of the SSD (including an invalid data address), the trim instruction together with a logical address that is updated

during an operation. In this way, in subsequent garbage collection processing, invalid data can be wiped, so that a user storage space capacity and an over provisioning space capacity are correspondingly increased, write amplification WA is reduced, and performance is improved. According to this embodiment of the present invention, the host is further required to deliver as many trim instructions as possible, so that the flash device can reversely adjust an over provisioning level. Because the delete instruction received by the processor 1001 may have been executed, the processor 1001 needs to determine whether the delete instruction has been executed. If the delete instruction has not been executed, it may be understood that the processor 1001 has not deleted data from the flash device according to the delete instruction. If the delete instruction has been executed, it may be understood that the processor 1001 has deleted, according to the delete instruction, data from the memory 1005. If the delete

instruction is received again, a size of data stored in the memory 1005 does not change. In this case, no processing is performed on the flash device. Determining the to-to-deleted data includes determining content and a volume of the to-be-deleted data, which may be understood as determining data that needs to be invalidated or a data block that needs to be
5 erased.

[0062] S205. Delete the to-be-deleted data from a flash device, and determine, as a size of data that is obtained after an operation and that is saved in the flash device by a user, a size of data that is obtained after the to-be-deleted data is deleted and that is saved by the user.

[0063] Optionally, the processor 1001 deletes the to-be-deleted data from the memory
10 1005, so as to decrease a size of data from a size of data previously saved in the memory 1005 by the user. The processor 1001 determines, as a size of data that is obtained after an operation and that is saved in the memory 1005 by the user, the size of the data that is obtained after the to-be-deleted data is deleted and that is saved by the user.

[0064] S206. Determine a target over provisioning level according to the size of the data
15 that is obtained after the operation and that is saved in the flash device by the user and an interval that is of a user storage space capacity and that is corresponding to each over provisioning level.

[0065] S207. Determine a target adjustment parameter according to the target over
provisioning level and a correspondence between each over provisioning level and an
20 adjustment parameter.

[0066] S208. Adjust an over provisioning space capacity of the flash device according to the target adjustment parameter.

[0067] For a specific implementation process of step S206 to step S208 in this embodiment of the present invention, refer to the specific descriptions of step S102 to step
25 S104 in the embodiment shown in FIG. 3. Details are not further described herein.

[0068] S209. Perform, according to a target garbage collection adjustment parameter in the target adjustment parameter, garbage collection processing on data stored in the flash device.

[0069] Optionally, the processor 1001 performs, according to the target garbage collection
30 adjustment parameter in the target adjustment parameter, garbage collection processing on the

data stored in the flash device. Garbage collection is: A primary controller of an SSD combines all "valid" data in those blocks including "invalid" data, puts combined data to a new "blank block", and deletes an "invalid" data block to increase a quantity of spare "blank blocks". It can be learned that, by means of garbage collection, not only a volume of invalid data is reduced, but a quantity of blank blocks is also increased, so that more available blank blocks are provided for the user.

[0070] Because garbage collection generates a large amount of load on an SSD, garbage collection may be classified into idle garbage collection and passive garbage collection. Idle garbage collection is: A primary controller of an SSD performs a garbage collection operation in advance when a system is idle, to generate a specific quantity of blank blocks, so that a garbage collection operation does not obviously affect user experience, but a disadvantage is that extra write amplification is caused because valid data just obtained by means of garbage collection may become invalid due to updating performed by a user. Passive garbage collection is possessed by all SSDs. Primary controller performance of an SSD has decisive impact on efficiency of passive garbage collection because the SSD in this case needs to simultaneously perform garbage collection and a data operation that is required by the user. When the primary controller performance is poor, the user finds that performance of the SSD deteriorates. Passive garbage collection is: performing a garbage collection operation according to a trim instruction sent by an associated host, so as to trigger the SSD to generate more data on an invalid page, relieve pressure of garbage collection, and reduce an opportunity that the user finds that the performance of the SSD deteriorates.

[0071] A garbage collection adjustment parameter is used for determining when to perform a garbage collection processing operation on the flash device, that is, the garbage collection adjustment parameter is a parameter used for starting garbage collection. In the prior art, in a case of a fixed over provisioning ratio, regardless of a size of data stored in an SSD, garbage collection processing is performed on the SSD according to a fixed garbage collection parameter, and consequently, performance and reliability of the SSD are affected. Because optimal adjustment parameters are separately configured for different space over provisioning levels in this embodiment of the present invention, appropriate garbage collection processing can be performed according to a volume of stored data in this

embodiment of the present invention, so as to optimize performance of the SSD.

[0072] S210. Perform, according to a target wear leveling adjustment parameter in the target adjustment parameter, wear leveling processing on data stored in the flash device.

[0073] Optionally, the processor 1001 performs, according to the target wear leveling
5 adjustment parameter in the target adjustment parameter, wear leveling processing on the data stored in the flash device, to ensure that quantities of times for which all blocks are written are equal. There are two types of wear leveling algorithms: a dynamic wear leveling algorithm and a static wear leveling algorithm. In brief, dynamic wear leveling means using a newest flash block each time instead of using an old flash block, and static wear leveling means
10 moving old data that has not been modified for a long time out of a new flash block and saving the old data in an oldest flash block, so that the new flash block can be frequently used again. Both static wear leveling and static wear leveling need a start granularity. A wear leveling adjustment parameter is a parameter used for determining when to start a wear leveling processing operation. Each over provisioning level is corresponding to a different
15 wear adjustment parameter, and an over provisioning level corresponding to a larger over provisioning ratio is corresponding to a larger start granularity.

[0074] In this embodiment of the present invention, an operation instruction sent by a host is received, an operation is performed, according to the operation instruction, on data stored in a flash device, and a size of data that is obtained after the operation and that is saved in the
20 flash device by a user is determined; then, a target over provisioning level is determined according to the size of the data that is obtained after the operation and that is saved in the flash device by the user and an interval that is of a user storage space capacity and that is corresponding to each over provisioning level, and a target adjustment parameter is determined according to the target over provisioning level and a correspondence between
25 each over provisioning level and an adjustment parameter; finally, an over provisioning space capacity of the flash device is adjusted according to the target adjustment parameter, and the flash device is correspondingly adjusted according to the target adjustment parameter. Therefore, an over provisioning ratio of the flash device is dynamically adjusted according to a volume of stored data, and further, reliability and performance stability of the flash device
30 are improved, a service life of the flash device is prolonged, and proactivity of the flash

device is improved.

[0075] In the following, a data processing apparatus according to an embodiment of the present invention is described in detail with reference to FIG. 6. It should be noted that the data processing apparatus shown in FIG. 6 is configured to perform the methods in the
5 embodiments shown in FIG. 4 and FIG. 5. For ease of description, only a part related to this embodiment of the present invention is shown. For undisclosed specific technical details, refer to the embodiments shown in FIG. 4 and FIG. 5 of the present invention.

[0076] The data processing apparatus in this embodiment of the present invention is applied to a flash device in the storage system shown in FIG. 1. Multiple over provisioning
10 levels are configured for physical storage space of the flash device according to multiple different over provisioning ratios, each over provisioning level is corresponding to an interval of a user storage space capacity, each interval of the user storage space capacity is corresponding to a different adjustment parameter, the over provisioning ratio is a ratio of an
15 over provisioning space capacity to the user storage space capacity, and the over provisioning space capacity is a difference between a physical storage space capacity and the user storage space capacity.

[0077] Referring to FIG. 6, FIG. 6 is a schematic structural diagram of a data processing apparatus according to the present invention. The data processing apparatus 10 may include a
20 receiving unit 101, a determining unit 102, and an adjustment unit 103.

[0078] The receiving unit 101 is configured to: receive an operation instruction sent by a host, perform, according to the operation instruction, an operation on data stored in a flash device, and determine a size of data that is obtained after the operation and that is saved in the
flash device by a user.

[0079] The determining unit 102 is configured to determine a target over provisioning
25 level according to the size of the data that is obtained after the operation and that is saved in the flash device by the user and an interval that is of a user storage space capacity and that is corresponding to each over provisioning level.

[0080] The determining unit 102 is further configured to determine a target adjustment parameter according to the target over provisioning level and a correspondence between each
30 over provisioning level and an adjustment parameter.

[0081] The adjustment unit 103 is configured to adjust an over provisioning space capacity of the flash device according to the target adjustment parameter.

[0082] This embodiment of the present invention and the method embodiment shown in FIG. 4 are based on a same concept, and produce a same technical effect. For a specific principle, refer to the description in the embodiment shown in FIG. 4, and details are not further described herein.

[0083] Optionally, the receiving unit 101 is specifically configured to: receive a write instruction sent by the host, determine to-be-added data according to the write instruction, add the to-be-added data to the flash device, and determine, as the size of the data that is obtained after the operation and that is saved in the flash device by the user, a size of data that is obtained after the to-be-added data is added to the flash device and that is saved by the user.

[0084] The receiving unit 101 is specifically configured to: receive a delete instruction sent by the host, determine to-be-deleted data according to the delete instruction, delete the to-be-deleted data from the flash device, and determine, as the size of the data that is obtained after the operation and that is saved in the flash device by the user, a size of data that is obtained after the to-be-deleted data is deleted and that is saved by the user.

[0085] The receiving unit 101 is further configured to compress the to-be-added data, and the to-be-added data is compressed data.

[0086] The data processing apparatus 10 further includes:

a processing unit, configured to perform, according to a target garbage collection adjustment parameter in the target adjustment parameter, garbage collection processing on the data stored in the flash device.

[0087] The processing unit is further configured to perform, according to a target wear leveling adjustment parameter in the target adjustment parameter, wear leveling processing on the data stored in the flash device.

[0088] This embodiment of the present invention and the method embodiment shown in FIG. 5 are based on a same concept, and produce a same technical effect. For a specific principle, refer to the description in the embodiment shown in FIG. 5, and details are not further described herein.

[0089] A person of ordinary skill in the art may understand that all or some of the

processes of the methods in the embodiments may be implemented by a computer program instructing relevant hardware. The program may be stored in a computer readable storage medium. When the program runs, the processes of the methods in the embodiments are performed. The foregoing storage medium may include: a magnetic disk, an optical disc, a
5 read-only memory (Read-Only Memory, ROM), or a random access memory (Random Access Memory, RAM).

[0090] What is disclosed above is merely examples of embodiments of the present invention, and certainly is not intended to limit the protection scope of the present invention. Therefore, equivalent variations made in accordance with the claims of the present invention
10 shall fall within the scope of the present invention.

CLAIMS

1. A method for adjusting storage spaces in a flash device, wherein the flash device comprises a data storage space for storing user data and an over provisioning space, the method comprising:

receiving, by a controller of the flash device, an operation instruction from a host device coupled to the flash device;

performing, by the controller, an operation on the user data stored in the data storage space according to the operation instruction, wherein before performing the operation, the data storage space already stores the user data having an initial size;

determining, by the controller, a changed size of the user data after performing the operation;

identifying, by the controller, a target over provisioning level according to the changed size of the user data, wherein the target over provisioning level is one of a plurality of different over provisioning levels preset for the flash device; and

adjusting, by the controller, capacities of the data storage space and the over provisioning space according to the target over provisioning level.

2. The method according to claim 1, wherein adjusting the capacities of the data storage space and the over provisioning space comprises:

when the changed size of the user data is larger than the initial size of the user data, and a difference between the changed size of the user data and a capacity of the data storage space is smaller than a first adjustment threshold, increasing the capacity of the data storage space and decreasing the capacity of the over provisioning space; and

when the changed size of the user data is smaller than the initial size of the user data, and a difference between the changed size of the user data and the capacity of the data storage space is larger than a second adjustment threshold, decreasing the capacity of the data storage space and increasing the capacity of the over provisioning space.

3. The method according to claim 1, wherein each over provisioning level corresponds to an adjustment parameter, and wherein adjusting the capacities of the data storage space and the over provisioning space according to the target over provisioning level comprises:

determining a target adjustment parameter based on the target over provisioning level;
and

adjusting the capacities of the data storage space and the over provisioning space according to the target adjustment parameter.

4. The method according to claim 3, wherein the target adjustment parameter comprises an over provisioning space adjustment parameter, and adjusting the capacities of the data storage space and the over provisioning space according to the target adjustment parameter comprises:

adjusting the capacity of the over provisioning space capacity according to the over provisioning space adjustment parameter.

5. The method according to claim 4, wherein the target adjustment parameter further comprises a garbage collection adjustment parameter, and wherein the method further comprises:

performing, by the controller according to the garbage collection adjustment parameter, garbage collection on the user data.

6. The method according to claim 4, wherein the target adjustment parameter further comprises a wear leveling adjustment parameter, and wherein the method further comprises:

performing, by the controller according to the wear leveling adjustment parameter, wear leveling on the user data.

7. The method according to claim 1, wherein the operation instruction includes a write instruction comprising to-be-added data, wherein performing the operation on the user data stored in the data storage space comprises:

writing the to-be-added data into the data storage space, wherein the changed size of the user data equals to the initial size of the user data plus a size of the to-be-added data.

8. The method according to claim 1, wherein the operation instruction includes a delete instruction comprising to-be-deleted data, wherein performing the operation on the user data stored in the data storage space comprises:

deleting the to-be-deleted data from the data storage space,
wherein the changed size of the user data equals to the initial size of the user data minus a size of the to-be-deleted data.

9. A flash device, comprising:

a storage medium providing storage space, and a controller;
wherein the storage space includes a data storage space for storing user data and an over provisioning space;

wherein the controller is configured to:

receive an operation instruction from a host device coupled to the flash device;
perform an operation on the user data stored in the data storage space according to the operation instruction, wherein before performing the operation, the data storage space already stores the user data having an initial size;

determine a changed size of the user data after performing the operation;
identify a target over provisioning level according to the changed size of the user data, wherein the target over provisioning level is one of a plurality of different over provisioning levels preset for the flash device; and

adjust the capacities of the data storage space and the over provisioning space according to the target over provisioning level.

10. The flash device according to claim 9, wherein in adjusting the capacities of the data storage space and the over provisioning space, the controller is configured to:

when the changed size of the user data is larger than the initial size of the user data, and a difference between the changed size of the user data and a capacity of the data storage space is

smaller than a first adjustment threshold, increase the capacity of the data storage space and decrease the capacity of the over provisioning space; and

when the changed size of the user data is smaller than the initial size of the user data, and a difference between the changed size of the user data and the capacity of the data storage space is larger than a second adjustment threshold, decrease the capacity of the data storage space and increase the capacity of the over provisioning space.

11. The flash device according to claim 9, wherein each over provisioning level corresponds to an adjustment parameter, and wherein in adjusting the capacities of the data storage space and the over provisioning space according to the target over provisioning level, the controller is configured to:

determine a target adjustment parameter based on the target over provisioning level; and adjust the capacities of the data storage space and the over provisioning space according to the target adjustment parameter.

12. The flash device according to claim 11, wherein the target adjustment parameter comprises an over provisioning space adjustment parameter, and wherein in adjusting the capacities of the data storage space and the over provisioning space, the controller is configured to:

adjust the capacity of the over provisioning space capacity according to the over provisioning space adjustment parameter.

13. The flash device according to claim 12, wherein the target adjustment parameter further comprises a garbage collection adjustment parameter, and wherein the controller is further configured to:

perform, according to the garbage collection adjustment parameter, garbage collection on the user data.

14. The flash device according to claim 12, wherein the target adjustment parameter further comprises a wear leveling adjustment parameter, and wherein the controller is further

configured to:

perform, according to the wear leveling adjustment parameter, wear leveling on the user data.

15. The flash device according to claim 9, wherein the operation instruction includes a write instruction comprising to-be-added data, wherein in performing the operation on the user data stored in the data storage space, the controller is configured to:

write the to-be-added data into the data storage space, wherein the changed size of the user data equals to the initial size of the user data plus a size of the to-be-added data.

16. The flash device according to claim 9, wherein the operation instruction includes a delete instruction comprising to-be-deleted data, wherein in performing the operation on the user data stored in the data storage space, the controller is configured to:

delete the to-be-deleted data from the data storage space, wherein the changed size of the user data equals to the initial size of the user data minus a size of the to-be-deleted data.

17. A method for adjusting storage spaces in a flash device, wherein the flash device comprises a data storage space for storing user data and an over provisioning space, the method comprising:

receiving, by a controller of the flash device, a write data request from a host device coupled to the flash device, wherein the write data request includes target data to be stored in the data storage space;

writing, by the controller, the target data into the data storage space according to the write data request;

determining, by the controller, a total size of the user data in the storage space after the target data is written to the storage space;

identifying, by the controller, a target over provisioning level according to the total size of the user data, wherein the target over provisioning level is one of a plurality of different over provisioning levels preset for the flash device; and

adjusting, by the controller, capacities of the data storage space and the over provisioning

space according to the target over provisioning level.

18. The method according to claim 17, wherein adjusting the capacities of the data storage space and the over provisioning space according to the total size of the user data comprises:

when a difference between the total size of the user data and a capacity of the data storage space is smaller than a first adjustment threshold, increase the capacity of the data storage space and decrease the capacity of the over provisioning space; and

when the difference between the total size of the user data and the capacity of the data storage space is larger than a second adjustment threshold, decrease the capacity of the data storage space and increase the capacity of the over provisioning space.

19. A flash device, comprising:

a storage medium providing storage space, and a controller;

wherein the storage space includes a data storage space for storing user data and an over provisioning space;

wherein the controller is configured to:

receive a write data request from a host device coupled to the flash device, wherein the write data request includes target data to be stored in the data storage space;

write the target data into the data storage space according to the write data request;

determine a total size of the user data in the storage space after the target data is written to the storage space;

identify a target over provisioning level according to the total size of the user data, wherein the target over provisioning level is one of a plurality of different over provisioning levels preset for the flash device; and

adjust capacities of the data storage space and the over provisioning space according to the determined target over provisioning level.

20. The flash device according to claim 19, wherein in adjusting the capacities of the data storage space and the over provisioning space according to the total size of the user data, the controller is configured to:

when a difference between the total size of the user data and a capacity of the data storage space is smaller than a first adjustment threshold, increase the capacity of the data storage space and decrease the capacity of the over provisioning space; and

when the difference between the total size of the user data and the capacity of the data storage space is larger than a second adjustment threshold, decrease the capacity of the data storage space and increase the capacity of the over provisioning space.