performance of the storage system.

SUMMARY

Embodiments of the present invention provide a storage system, a method, and an apparatus for processing an operation request.

According to a first aspect, an embodiment of the present invention provides a storage system for processing an operation request, where the storage system includes a controller and a disk enclosure, and the controller communicates with the disk enclosure by using an Ethernet network; the controller includes a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control (MAC) address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface (SAS) protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure;

the back-end adapter is configured to: receive a Small Computer System Interface (SCSI) protocol operation request sent by the central processing unit, where the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk; query a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk according to the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure; encapsulate the SCSI protocol operation request into an Ethernet operation request packet; and send the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure, where the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure; and

the disk enclosure is configured to: receive and decapsulate the Ethernet operation request packet, to obtain the SCSI protocol operation request; and send the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

With reference to the first aspect of the present invention, in a first possible implementation manner of the first aspect, the disk enclosure is further configured to establish a correspondence

between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller;

the disk enclosure is further configured to: receive a SCSI protocol operation request response that is sent by the target disk according to the SCSI protocol operation request, where the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller; query the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller according to the SCSI protocol transaction identifier of the controller, to obtain the MAC address of the back-end adapter; encapsulate the SCSI protocol operation request response into an Ethernet operation request response packet; and send the Ethernet operation request response packet to the controller according to the MAC address of the back-end adapter, where the Ethernet operation request response packet carries the MAC address of the back-end adapter; and

the back-end adapter is further configured to: receive and decapsulate the Ethernet operation request response packet, to obtain the SCSI protocol operation request response; and send the SCSI protocol operation request response to the central processing unit.

With reference to the first possible implementation manner of the first aspect of the present invention, in a second possible implementation manner of the first aspect, the back-end adapter is further configured to: encapsulate the SCSI protocol transaction identifier of the controller in the SCSI protocol operation request into a first field of the Ethernet operation request packet; and encapsulate the SAS protocol address of the target disk in the SCSI protocol operation request into a second field of the Ethernet operation request packet, where the first field, the second field, and a field carrying the SCSI protocol operation request are three different fields;

that the disk enclosure establishes a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller specifically includes: the disk enclosure decapsulates the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller, and establishes the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and

that the disk enclosure sends the SCSI protocol operation request to the target disk

according to the SAS protocol address of the target disk specifically includes: the disk enclosure decapsulates the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk, and sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

According to a second aspect, an embodiment of the present invention provides a method for processing an operation request, where the method is applied to a controller, and the controller communicates with a disk enclosure by using an Ethernet network; the controller includes a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure; and

the method includes:

sending, by the central processing unit, a Small Computer System Interface SCSI protocol operation request, where the SCSI protocol operation request carries a SAS protocol address of a target disk; and

receiving, by the back-end adapter, the SCSI protocol operation request sent by the central processing unit; querying a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk according to the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure; encapsulating the SCSI protocol operation request into an Ethernet operation request packet carrying the MAC address of the back-end adapter and the MAC address of the disk enclosure; and sending the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure.

With reference to the second aspect, in a first possible implementation manner of the second aspect, the SCSI protocol operation request further carries a SCSI protocol transaction identifier of the controller, and the method further includes: encapsulating the SCSI protocol transaction identifier of the controller into a first field of the Ethernet operation request packet, and encapsulating the SAS protocol address of the target disk into a second field of the Ethernet

operation request packet, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields.

With reference to the first possible implementation manner of the second aspect, in a second possible implementation manner, the method further includes:

receiving and decapsulating, by the back-end adapter, an Ethernet response packet for the Ethernet operation request packet that is sent by the disk enclosure, to obtain a SCSI protocol operation request response; and sending the SCSI protocol operation request response to the central processing unit, where the Ethernet response packet for the Ethernet operation request packet carries the MAC address of the back-end adapter; and

receiving, by the central processing unit, the SCSI protocol operation request response.

According to a third aspect, an embodiment of the present invention provides a method for processing an operation request, where the method is applied to a disk enclosure, and a controller communicates with the disk enclosure by using an Ethernet network; the controller includes a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; and

the method includes:

receiving and decapsulating, by the disk enclosure, an Ethernet operation request packet sent by the controller, to obtain a Small Computer System Interface SCSI protocol operation request, where the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure, and the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk; and

sending, by the disk enclosure, the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

With reference to the third aspect, in a first possible implementation manner of the third aspect, the method further includes: establishing, by the disk enclosure, a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller;

receiving, by the disk enclosure, a SCSI protocol operation request response that is sent by the target disk according to the SCSI protocol operation request, where the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller;

querying, by the disk enclosure, the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller according to the SCSI protocol transaction identifier of the controller, to obtain the MAC address of the back-end adapter;

encapsulating, by the disk enclosure, the SCSI protocol operation request response into an Ethernet operation request response packet, where the Ethernet operation request response packet carries the MAC address of the back-end adapter; and

sending, by the disk enclosure, the Ethernet operation request response packet to the controller according to the MAC address of the back-end adapter.

With reference to the first possible implementation manner of the third aspect, in a second possible implementation manner of the third aspect, a first field of the Ethernet operation request packet carries the SCSI protocol transaction identifier of the controller, and a second field of the Ethernet operation request packet carries the SAS protocol address of the target disk, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields;

the establishing, by the disk enclosure, a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller specifically includes: decapsulating, by the disk enclosure, the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller, and establishing the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and

the sending, by the disk enclosure, the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk specifically includes: decapsulating, by the disk enclosure, the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk, and sending the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

According to a fourth aspect, an embodiment of the present invention provides a

controller, where the controller is applied to a storage system, and the storage system includes the controller and a disk enclosure; the controller communicates with the disk enclosure by using an Ethernet network; the controller includes a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure;

the central processing unit is configured to send a Small Computer System Interface SCSI protocol operation request, where the SCSI protocol operation request carries a SAS protocol address of a target disk; and

the back-end adapter is configured to: receive the SCSI protocol operation request; query a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk according to the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure; encapsulate the SCSI protocol operation request into an Ethernet operation request packet; and send the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure, where the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure.

With reference to the fourth aspect, in a first possible implementation manner of the fourth aspect, the SCSI protocol operation request further carries a SCSI protocol transaction identifier of the controller; and the back-end adapter is further configured to: encapsulate the SCSI protocol transaction identifier of the controller into a first field of the Ethernet operation request packet, and encapsulate the SAS protocol address of the target disk into a second field of the Ethernet operation request packet, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields.

With reference to the first possible implementation manner of the fourth aspect, in a second possible implementation manner of the fourth aspect, the back-end adapter is further configured to: receive

and decapsulate an Ethernet response packet for the Ethernet operation request packet that is sent by the disk enclosure, to obtain a SCSI protocol operation request response; and send the SCSI protocol operation request response to the central processing unit, where the Ethernet response packet for the Ethernet operation request packet carries the MAC address of the back-end adapter; and

the central processing unit is further configured to receive the SCSI protocol operation request response.

According to a fifth aspect, an embodiment of the present invention provides a disk enclosure, where the disk enclosure is applied to a storage system, and the storage system includes a controller and the disk enclosure; the controller includes a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; the controller communicates with the disk enclosure by using an Ethernet network; and the disk enclosure includes:

a first transceiver unit, configured to receive an Ethernet operation request packet sent by the controller, where the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure;

an encapsulating and decapsulating unit, configured to decapsulate the Ethernet operation request packet received by the first transceiver unit, to obtain a Small Computer System Interface SCSI protocol operation request, where the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk; and

a second transceiver unit, configured to send the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

With reference to the fifth aspect, in a first possible implementations manner of the fifth aspect, the disk enclosure further includes an establishing unit and a querying unit, where:

the establishing unit is configured to establish a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller;

the second transceiver unit is further configured to receive a SCSI protocol operation

request response that is sent by the target disk according to the SCSI protocol operation request, where the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller;

the querying unit is configured to query, according to the SCSI protocol transaction identifier of the controller, the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller that is established by the establishing unit, to obtain the MAC address of the back-end adapter;

the encapsulating and decapsulating unit is further configured to encapsulate the SCSI protocol operation request response into an Ethernet operation request response packet, where the Ethernet operation request response packet carries the MAC address of the back-end adapter; and

the first transceiver unit is further configured to send the Ethernet operation request response packet to the controller according to the MAC address of the back-end adapter.

With reference to the first possible implementation manner of the fifth aspect, in a second possible implementation manner of the fifth aspect, a first field of the Ethernet operation request packet carries the SCSI protocol transaction identifier of the controller, and a second field of the Ethernet operation request packet carries the SAS protocol address of the target disk, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields;

that the establishing unit establishes a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller specifically includes: the encapsulating and decapsulating unit decapsulates the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller, and the establishing unit establishes the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and

that the second transceiver unit sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk specifically includes: the encapsulating and decapsulating unit decapsulates the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk, and the second transceiver unit sends the SCSI protocol operation request to the target disk according to the

SAS protocol address of the target disk.

According to a sixth aspect, an embodiment of the present invention provides a back-end adapter, where the back-end adapter is applied to a controller of a storage system, and the storage system includes the controller and a disk enclosure; the controller communicates with the disk enclosure by using an Ethernet network; the controller includes a central processing unit and the back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure; and

the back-end adapter includes:

a first transceiver unit, configured to send a Small Computer System Interface SCSI protocol operation request, where the SCSI protocol operation request carries a SAS protocol address of a target disk;

a querying unit, configured to query a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure;

an encapsulating and decapsulating unit, configured to encapsulate the SCSI protocol operation request into an Ethernet operation request packet, where the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure; and

a second transceiver unit, configured to send the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure.

With reference to the sixth aspect, in a first possible implementation manner of the sixth aspect, the SCSI protocol operation request further carries a SCSI protocol transaction identifier of the controller; and the encapsulating and decapsulating unit is further configured to encapsulate the SCSI protocol transaction identifier of the controller into a first field of the Ethernet operation request packet, and encapsulate the SAS protocol address of the target disk into a second field, where the first field, the second field, and a field that is in the Ethernet operation

request packet and carries the SCSI protocol operation request are three different fields.

With reference to the first impossible implementation manner of the sixth aspect, in a second possible implementation manner of the sixth aspect, the second transceiver unit is further configured to receive an Ethernet response packet for the Ethernet operation request packet that is sent by the disk enclosure, where the Ethernet response packet for the Ethernet operation request packet carries the MAC address of the back-end adapter;

the encapsulating and decapsulating unit is further configured to decapsulate the Ethernet response packet for the Ethernet operation request packet, to obtain a SCSI protocol operation request response; and

the first transceiver unit is further configured to send the SCSI protocol operation request response to the central processing unit.

According to a seventh aspect, an embodiment of the present invention provides a back-end adapter, where the back-end adapter is applied to a controller of a storage system, and the storage system includes the controller and a disk enclosure; the controller communicates with the disk enclosure by using an Ethernet network; the controller includes a central processing unit and the back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure; and

the back-end adapter includes a first interface, a second interface, a memory, and a first central processing unit, where the first interface is configured to receive a Small Computer System Interface SCSI protocol operation request sent by the central processing unit, where the SCSI protocol operation request carries a SAS protocol address of a target disk;

the first central processing unit executes a computer instruction in the memory, to implement the following operations:

querying a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk according to the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure; and encapsulating the SCSI protocol operation

request into an Ethernet operation request packet, where the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure; and

the second interface is configured to send the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure.

With reference to the seventh aspect, in a first possible implementation manner of the seventh aspect, the SCSI protocol operation request further carries a SCSI protocol transaction identifier of the controller; and the first central processing unit executes the computer instruction in the memory, and further implements the following operations:

encapsulating the SCSI protocol transaction identifier of the controller into a first field of the Ethernet operation request packet, and encapsulating the SAS protocol address of the target disk into a second field, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields.

With reference to the first impossible implementation manner of the seventh aspect, in a second possible implementation manner of the seventh aspect, the second interface is further configured to receive an Ethernet response packet for the Ethernet operation request packet that is sent by the disk enclosure, where the Ethernet response packet for the Ethernet operation request packet carries the MAC address of the back-end adapter;

the first central processing unit executes the computer instruction in the memory, and is further configured to implement the following operation:

decapsulating the Ethernet response packet for the Ethernet operation request packet, to obtain a SCSI protocol operation request response; and

the first interface is further configured to send the SCSI protocol operation request response to the central processing unit.

According to an eighth aspect, an embodiment of the present invention provides a disk enclosure, where the disk enclosure is applied to a storage system, and the storage system includes a controller and the disk enclosure; the controller communicates with the disk enclosure by using an Ethernet network; the controller includes a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access

control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; and

the disk enclosure includes: a front-end interface, a back-end interface, a first central processing unit, and a first memory, where:

the front-end interface is configured to receive and decapsulate an Ethernet operation request packet sent by the controller, to obtain a Small Computer System Interface SCSI protocol operation request, and send the SCSI protocol operation request to the first central processing unit, where the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure, and the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk;

the first central processing unit executes a computer instruction in the first memory, to implement the following operations:

receiving the SCSI protocol operation request, and sending the SCSI protocol operation request to the back-end interface; and

the back-end interface is configured to receive the SCSI protocol operation request, and send the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

With reference to the eighth aspect, in a first possible implementation manner of the eighth aspect, the first central processing unit executes the computer instruction in the first memory, and further implements the following operation:

establishing a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and the back-end interface is configured to send the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk;

the back-end interface is further configured to receive a SCSI protocol operation request response that is sent by the target disk according to the SCSI protocol operation request, where the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller;

the first central processing unit executes the computer instruction in the first memory,

and further implements the following operation:

querying the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller according to the SCSI protocol transaction identifier of the controller carried in the SCSI protocol operation request response, to obtain the MAC address of the back-end adapter; and

the front-end interface is further configured to: receive the SCSI protocol operation request response sent by the first central processing unit; encapsulate the SCSI protocol operation request response into an Ethernet operation request response packet according to the MAC address of the back-end adapter that is obtained by the first central processing unit; and send the Ethernet operation request response packet to the controller according to the MAC address of the back-end adapter, where the Ethernet operation request response packet carries the MAC address of the back-end adapter.

With reference to the first possible implementation manner of the eighth aspect, in a second possible implementation manner of the eighth aspect, a first field of the Ethernet operation request packet carries the SCSI protocol transaction identifier of the controller, and a second field of the Ethernet operation request packet carries the SAS protocol address of the target disk, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields;

the establishing a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller specifically includes:

decapsulating, by the front-end interface, the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller, and establishing, by an establishing unit of the first central processing unit, the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and

that the back-end interface sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk specifically includes: the front-end interface decapsulates the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk, and the back-end interface sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

protocol; send, according to the read operation request or write operation request, a read operation request or a write operation request that is based on a second protocol to a target disk among the disks 1031...103n, 1041...104n; and send, according to a read operation request response or a write operation request response that is sent by the target disk and based on the second protocol, a read operation request response or a write operation request response that is based on the first protocol to the controller 101, where the first protocol and the second protocol may be different protocols and are specifically determined by an application scenario. Specifically, in this embodiment of the present invention, the first protocol is an Ethernet communications protocol, and the second protocol is the SAS protocol. The back-end interface 1024 of the disk enclosure 102 communicates with SAS protocol interfaces of the disks 1031...103n, 1041...104n by using the SCSI protocol and a SAS protocol interface. Specifically, the front-end interface 1021 of the disk enclosure 102 is configured to: receive and decapsulate an Ethernet operation request packet sent by the controller 101, to obtain a SCSI protocol operation request; and send the SCSI protocol operation request to the central processing unit 1022. The Ethernet operation request packet carries a MAC address of the back-end adapter 1014 and a MAC address of the disk enclosure 102; and the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller 101 and a SAS protocol address of a target disk 1031, where the SCSI protocol transaction identifier is used to uniquely identify a specific SCSI protocol transaction link established between the controller 101 and the target disk 1031, and the target disk 1031 refers to a disk accessed by the SCSI protocol operation request.

The processing unit 1022 executes a computer instruction in the memory 1023, to implement the following operations: receiving the SCSI protocol operation request, establishing a correspondence between the MAC address of the back-end adapter 1014 and the SCSI protocol transaction identifier of the controller 101, and send the SCSI protocol operation request to the back-end interface 1024 according to the SAS protocol address of the target disk 1031. According to the SAS protocol address of the target disk 1031, an implementation manner is: parsing the SCSI protocol operation request to obtain the SAS protocol address of the target disk 1031.

The back-end interface 1024 is configured to receive the SCSI protocol operation request,

and send the SCSI protocol operation request to the target disk 1031; and the back-end interface 1024 is further configured to receive a SCSI protocol operation request response that is sent by the target disk 1031 according to the SCSI protocol operation request, where the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller 101.

Correspondingly, the central processing unit 1022 executes the computer instruction in the memory 1023, and further implements the following operation: querying the correspondence between the MAC address of the back-end adapter 1014 and the SCSI protocol transaction identifier of the controller 101 according to the SCSI protocol transaction identifier of the controller 101 carried in the SCSI protocol operation request response, to obtain the MAC address of the back-end adapter 1014; and the front-end interface 1201 is further configured to: receive the SCSI protocol operation request response sent by the central processing unit 1022; encapsulate, according to the MAC address of the back-end adapter 1014 obtained by the central processing unit 1022, the SCSI protocol operation request response into an Ethernet operation request response packet that carries the MAC address of the back-end adapter 1014; and send the Ethernet operation request response packet to the controller 101 according to the MAC address of the back-end adapter 1014.

In another implementation manner, the back-end adapter 1014 encapsulates the SCSI protocol operation request into the Ethernet operation request packet, encapsulates the SCSI protocol transaction identifier of the controller 101 carried in the SCSI protocol operation request into a first field of the Ethernet operation request packet, encapsulates the SAS protocol address of the target disk 1031 into a second field, and sends the Ethernet operation request packet to the disk enclosure 102, where the first field, the second field, and a field carrying the SCSI protocol operation request are three different fields. The disk enclosure 102 decapsulates the Ethernet operation request packet, obtains the SAS protocol address of the target disk from the foregoing second field, instead of parsing the field carrying the SCSI protocol operation request to obtain the SCSI protocol transaction identifier of the controller 101 and the SAS protocol address of the target disk from the SCSI protocol operation request, and sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk. The disk enclosure 102 obtains the SCSI protocol transaction

identifier of the controller 101 from the foregoing first field, and establishes the correspondence between the SCSI protocol transaction identifier of the controller 101 and the MAC address of the back-end adapter 1014 according to the SCSI protocol transaction identifier of the controller 101 obtained from the foregoing first field. In this implementation manner, after decapsulating the Ethernet operation request packet, the disk enclosure 102 can establish the correspondence between the SCSI protocol transaction identifier of the controller 101 and the MAC of the back-end adapter 101, and send the SCSI protocol operation request to the target disk, without a need to parse the SCSI protocol operation request, thereby saving computation resources of the disk enclosure 102.

Exemplarily, the central processing unit 1022 of the disk enclosure 102 establishes the correspondence between the SCSI protocol transaction identifier of the controller 101 and the MAC address of the back-end adapter 1014. As shown in FIG. 4, the correspondence between the SCSI protocol transaction identifier of the controller 101 and the MAC address of the back-end adapter 1014 is stored in a form of a two-dimensional table. In specific computer implementation, the two-dimensional table may be stored in a form of a two-dimensional array or in a form that can be recognized by a computer, which is not limited by this embodiment of the present invention. Packet formats of the SCSI protocol operation request response packet and the Ethernet operation request response packet respectively correspond to those of the SCSI protocol operation request and the Ethernet operation request. A specific difference lies in different content carried in packet fields. Specifically, when in the Ethernet operation request packet, the first field is used to carry the SCSI protocol transaction identifier of the controller, and the second field is used to carry the destination SAS protocol address, in the Ethernet operation request response packet, a first field still carries the SCSI protocol transaction identifier of the controller, and the destination SAS protocol address in a second field is empty.

The disk enclosure 102 described in FIG. 3a of the embodiment of the present invention may be specifically implemented by a computer having a general central processing unit, as shown in FIG. 3a. In another aspect, the disk enclosure 102 may be implemented jointly by an application-specific integrated circuit (ASIC), namely an ASIC commercial chip, and a memory, or may be implemented by a Field Programmable Gate Array (FPGA). In terms of

1014. In one implementation manner, a first field of the Ethernet operation request packet carries the SCSI protocol transaction identifier of the controller 101, and a second field of the Ethernet operation request packet carries the SAS protocol address of the target disk 1031, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields. That the establishing unit 1023' establishes a correspondence between the MAC address of the back-end adapter 1014 and the SCSI protocol transaction identifier of the controller 101 specifically includes: the encapsulating and decapsulating unit 1022' decapsulates the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller 101, and the establishing unit 1023' establishes the correspondence between the MAC address of the back-end adapter 1014 and the SCSI protocol transaction identifier of the controller 101. That the second transceiver unit 1024' sends the SCSI protocol operation request to the target disk 1031 according to the SAS protocol address of the target disk 1031 specifically includes: the encapsulating and decapsulating unit 1022' decapsulates the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk 1031, and the second transceiver unit 1024' sends the SCSI protocol operation request to the target disk 1031 according to the SAS protocol address of the target disk 1031.

In another embodiment based on FIG. 3b, the first field of the Ethernet operation request packet sent by the back-end adapter 1014 carries the SCSI protocol transaction identifier of the controller 101, and the second field carries the SAS protocol address of the target disk 1031, where in the Ethernet operation request packet, the first field, the second field, and a field carrying the SCSI protocol operation request are three different fields; and the establishing unit 1023' establishes the correspondence between the MAC address of the back-end adapter 1014 and the SCSI protocol transaction identifier of the controller 101, where the SCSI protocol transaction identifier of the controller 101 is obtained by the disk enclosure 102 from the first field by decapsulating the Ethernet operation request packet.

That the second transceiver unit 1024' sends the SAS protocol address of the target disk in the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk specifically includes: the encapsulating and decapsulating unit 1022' decapsulates the Ethernet operation request packet, to obtain the SAS protocol address of the

target disk from the second field, and the second transceiver unit 1024' sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk obtained from the second field. In this way, without a need to parse the SCSI protocol operation request, the correspondence between the SCSI protocol transaction identifier of the controller 101 and the MAC address of the back-end adapter 1014 can be established according to the SCSI protocol transaction identifier of the controller 101 carried in the first field, and the SCSI protocol operation request can be directly sent to the target disk 1031 according to the SAS protocol address of the target disk 1031 carried in the second field.

An embodiment of the present invention provides a method that can be implemented based on the structure shown in FIG. 2. As shown in FIG. 5, a detailed procedure of the method includes the following steps:

501: A central processing unit 1012 sends a SCSI protocol operation request to a back-end adapter 1014.

502: After receiving the SCSI protocol operation request, the back-end adapter 1014 queries a correspondence between a MAC address of a disk enclosure 102 and a SAS protocol address of a target disk 1031, to obtain the MAC address of the disk enclosure 102, and encapsulates the SCSI protocol operation request as an Ethernet operation request packet, where the Ethernet operation request packet carries a MAC address of the back-end adapter 1014 and the MAC address of the disk enclosure 102.

503: The back-end adapter 1014 sends the Ethernet operation request packet to the disk enclosure 102 according to the MAC address of the disk enclosure 102.

504: The disk enclosure 102 receives and decapsulates the Ethernet operation request packet, to obtain the SCSI protocol operation request, and establishes a correspondence between the MAC address of the back-end adapter 1014 and a SCSI protocol transaction identifier of the controller 101.

505: The disk enclosure 102 sends the SCSI protocol operation request to the target disk 1031 according to the SAS protocol address of the target disk 1031.

After receiving the SCSI protocol operation request, the target disk 1031 generates a SCSI protocol operation request response.

506: The disk enclosure 102 receives the SCSI protocol operation request response that

packet instead of using the TCP/IP layer. As can be seen from FIG. 7, the heartbeat broadcast packet sent by the back-end adapter 1014 is used as an Ethernet packet and includes a destination MAC address field, a source MAC address field, and a payload. A source MAC address bit carries the MAC address of the back-end adapter 1014. When the heartbeat broadcast packet is used as a broadcast packet~~As a broadcast packet~~, each bit in the destination MAC address field is 1. The payload of the heartbeat broadcast packet carries another field. The payload may include multiple fields, for example, a SCSI protocol packet-type field that is used to indicate a type of a SCSI protocol operation request, such as a SCSI protocol read operation request or a SCSI protocol write operation request; a SCSI protocol transaction identifier field that is used to uniquely identify a specific SCSI protocol transaction link established between a controller and a disk; and a destination SAS protocol address field that is used to indicate receiving of a SAS protocol address of a disk that is encapsulated into the SCSI protocol operation request, where a SAS protocol address of a target disk receiving a current SCSI protocol operation request can be recognized by using the field, without a need to parse and query a SCSI protocol frame data field to determine the SAS protocol address of the target disk. In the heartbeat broadcast packet, each bit of the destination SAS address field is 0. The payload further includes an operation code field, where the operation code field is used to indicate an operation type of a SCSI command and a data field. In the heartbeat broadcast packet~~As a heartbeat broadcast packet~~, the operation code field is 0x050, which is used to indicate a broadcast packet. FIG. 7 shows a packet format of a heartbeat broadcast packet. After receiving the heartbeat broadcast packet, the disk enclosure 102 decapsulates an Ethernet operation request packet, and determines, according to information carried in the destination SAS protocol address field, that the packet is a heartbeat broadcast packet, thereby improving a packet processing speed. In another implementation manner, a valid data field does not include the SCSI protocol transaction identifier field, the destination SAS protocol address field, or the SCSI protocol packet-type field. The payload of the heartbeat broadcast packet includes the SCSI protocol frame data field, where the SCSI protocol frame data field carries the SCSI protocol operation request, and the SCSI protocol transaction identifier of the controller 101 and the destination SAS protocol address that are carried in the heartbeat broadcast packet may be obtained from the SCSI protocol frame data field of the heartbeat broadcast packet. Although the heartbeat broadcast packet in an Ethernet operation request

packet format shown in FIG. 7 includes the destination MAC address field, the source MAC address field, and the payload, for a person skilled in the art, the Ethernet operation request packet may further include another field as required, and the payload may further include another field as required, which are not described herein again.

Exemplarily, as shown in FIG. 8, in a packet format of the heartbeat broadcast packet response sent by the disk enclosure 102 to the controller 101 in step 603, a destination MAC address field of the heartbeat broadcast packet response is the MAC address of the back-end adapter 1014, a source MAC address field carries the MAC address of the disk enclosure 102, an operation code field is 0x060, and a payload further includes a packet content identifier field that is used to carry a SAS protocol address of a disk that communicates with the disk enclosure 102.

Exemplarily, in step 605, the back-end adapter 1014 obtains, by paring the heartbeat broadcast packet response, the MAC address of the disk enclosure 102 and the SAS protocol address of each of the disks 1031...103n, 1041...104n. As shown in FIG. 9, the correspondence between the MAC address of the disk enclosure 102 and the SAS protocol address of each of the disks 1031...103n, 1041...104n is stored in a form of a two-dimensional table. In specific computer implementation, the two-dimensional table may be stored in a form of a two-dimensional array or in a form that can be recognized by a computer, which is not limited by this embodiment of the present invention. The disk enclosure 102 sends the heartbeat broadcast packet response to the controller 101. Specifically, the heartbeat broadcast packet response may carry the MAC address of the disk enclosure 102 and the SAS protocol addresses of all the disks 1031...103n, 1041...104n, or the heartbeat broadcast packet response may carry the MAC address of the disk enclosure 102 and SAS protocol addresses of some of the disks, where the correspondence between the MAC address of the disk enclosure 102 and the SAS protocol address of each of the disks 1031...103n, 1041...104n that is stored by the back-end adapter 1014 is updated and improved by exchanging a heartbeat broadcast packet and a heartbeat broadcast packet response between the controller 101 and disk enclosure 102 for multiple times. When a new disk is connected in the disk enclosure 102, the disk enclosure 102 receives a heartbeat broadcast packet sent by the controller 101, and sends, to the controller 101, a heartbeat broadcast packet response that

carries the MAC address of the disk enclosure 102 and a SAS protocol address of the new disk. In this embodiment of the present invention, another expression of saving the correspondence between the SCSI protocol transaction identifier of the controller 101 and the MAC address of the back-end adapter 1014 is: storing the correspondence between the SCSI protocol transaction identifier of the controller 101 and the MAC address of the back-end adapter 1014; and another expression of saving the correspondence between the MAC address of the disk enclosure 102 and the SAS protocol address of each of the disks 1031...103n, 1041...104n is: storing the correspondence between the MAC address of the disk enclosure 102 and the SAS protocol address of each of the disks 1031...103n, 1041...104n. Both expressions have a same meaning.

In this embodiment of the present invention, FIG. 10 shows a connection relationship between the central processing unit 1012 of the controller 101 and the back-end adapter 1014 of the controller 101 in the schematic structural diagram of the controller shown in FIG. 2. The front-end adapter 1011 and the back-end adapter 1014 communicate with the central processing unit 1012 through Peripheral Component Interconnect Express (PCIe) switching. Certainly, the front-end adapter 1011 and the back-end adapter 1014 are connected through PCIe switching. The implementation manner for communication with the central processing unit 1012 is only one of the implementation manners, and the communication may also be implemented by using a south bridge chip, which is not limited herein.

The controller structure shown in FIG. 10 is used as an example. The central processing unit 1012 of the controller 101 sends, to a target disk connected to the disk enclosure 102, a SCSI protocol operation request, such as a read operation request or a write operation request, which is not limited by the present invention. The SCSI protocol operation request may be sent to the target disk by the central processing unit 1012 according to an operation request that is received by the front-end adapter 1011 and sent by a server, which is not limited herein. Exemplarily, a packet format of the SCSI protocol operation request is a standard SCSI protocol packet format, and the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller 101 and a SAS protocol address of the target disk. The back-end adapter 1014 receives the SCSI protocol operation request, and queries a correspondence between a MAC address of the disk enclosure and the SAS protocol address

1031 is the MAC address of the disk enclosure 102. The SCSI protocol operation request and the MAC address of the disk enclosure 102 are sent to the protocol encapsulating and decapsulating module. As shown in FIG. 11, the protocol encapsulating and decapsulating module encapsulates the SCSI protocol operation request into a SCSI protocol frame data field, the SAS protocol address of the target disk 1031 is encapsulated into a destination SAS protocol address field, a SCSI protocol operation request type is encapsulated into a SCSI protocol packet-type field, a SCSI protocol transaction identifier of the controller 101 is encapsulated into a SCSI protocol transaction identifier field, and the SCSI protocol packet-type field, the SCSI protocol transaction identifier field, the destination SAS protocol address field, and the SCSI protocol frame data field are encapsulated into a payload of an Ethernet operation request packet, where in the Ethernet operation request packet, a destination MAC address field carries the MAC address of the disk enclosure 102, and a source MAC address field carries a MAC address of the back-end adapter 1014. In the payload of the Ethernet operation request packet, the destination SAS protocol address field, the SCSI protocol transaction identifier field, and the SCSI protocol frame data field carrying the SCSI protocol operation request are three different fields. In another implementation manner, the payload of the Ethernet operation request packet does not include the SCSI protocol transaction identifier field or the destination SAS protocol address field, and the disk enclosure 102 obtains the SAS address of the target disk 1031 and the SCSI protocol transaction identifier of the controller 101 from the SCSI protocol operation request carried in the SCSI protocol frame data field. The Ethernet module sends the Ethernet operation request packet to the disk enclosure 102 by using an Ethernet network. The Ethernet module includes a flow control module, a packet retransmission module, an Ethernet MAC module, and an Ethernet interface. The flow control module is configured to perform flow control processing when data congestion occurs on the Ethernet network, to avoid data packet loss caused by Ethernet congestion; the packet retransmission module is configured to retransmit a packet when a packet transmission error occurs on the Ethernet network, to ensure reliability of data transmission; and the Ethernet MAC module and the Ethernet interface, serving as an Ethernet MAC layer and an Ethernet physical interface layer, have a same meaning as an Ethernet MAC layer and an Ethernet physical interface layer in a standard Ethernet network structure.

transaction identifier and the MAC address of the back-end adapter 1014, and sends the SCSI protocol operation request to the target disk 1031 according to the SAS protocol address of the target disk 1031 through the back-end interface 1024.

After the Ethernet operation request packet carrying the SCSI protocol operation request is decapsulated, the MAC address of the back-end adapter 1014 is obtained. The SCSI protocol transaction identifier is obtained according to the SCSI protocol transaction identifier field in the payload. The central processing unit 1022 establishes the correspondence between the MAC address of the back-end adapter 1014 and the SCSI protocol transaction identifier of the controller 101. The back-end interface 1024 sends the SCSI protocol operation request to the target disk 1031 according to the SAS protocol address of the target disk 1031 carried in the destination SAS protocol address field in the payload. The central processing unit 1022 receives, through the back-end interface 1024, a SCSI protocol operation request response sent by the target disk 1031, where the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller 101, and queries the correspondence between the MAC address of the back-end adapter 1014 and the SCSI protocol transaction identifier of the controller 101 according to the SCSI protocol transaction identifier of the controller 101 carried in the SCSI protocol operation request response. The front-end interface 1021 receives the SCSI protocol operation request response sent by the central processing unit 1022 ~~and the MAC address of the back-end adapter 1014~~, and the front-end interface ~~1024~~ 1021 encapsulates the SCSI protocol operation request response into an Ethernet operation request response packet, where the Ethernet operation request response packet carries the MAC address of the back-end adapter 1014 and the MAC address of the front-end interface ~~adapter~~ 10241. For example, a destination MAC address field carries the MAC address of the back-end adapter 1014, a source MAC address field carries the MAC address of the disk enclosure 102, a SCSI protocol transaction identifier field carries the SCSI protocol transaction identifier of the controller 101, and a SCSI protocol packet-type field carries a type of the SCSI protocol operation request. In this embodiment of the present invention, the Ethernet operation request response packet may also be called an Ethernet response packet for the Ethernet operation request packet, and both have a same meaning. In one implementation manner, in a payload of the Ethernet operation request response packet, a SCSI protocol frame data field carries the

structure shown in FIG. 13, and includes a first transceiver unit 1301, a querying unit 1302, an encapsulating and decapsulating unit 1303, and a second transceiver unit 1304. The first transceiver unit 1301 is configured to receive a SCSI protocol operation request sent by a central processing unit 1012, where the SCSI protocol operation request carries a SAS protocol address of a target disk 1031; the querying unit 1302 is configured to query a correspondence between a MAC address of a disk enclosure 102 and the SAS protocol address of the target disk 1031, to obtain the MAC address of the disk enclosure 102; the encapsulating and decapsulating unit 1303 is configured to encapsulate the SCSI protocol operation request into an Ethernet operation request packet, where the Ethernet operation request packet carries a MAC address of the back-end adapter 1014 and the MAC address of the disk enclosure 102; and the second transceiver unit 1304 is configured to send the Ethernet operation request packet to the disk enclosure 102 according to the MAC address of the disk enclosure 102. Further, the SCSI protocol operation request further carries a SCSI protocol transaction identifier of the controller 101, and the encapsulating and decapsulating unit 1303 is further configured to encapsulate the SCSI protocol transaction identifier of the controller 101 into a first field of the Ethernet operation request packet, and encapsulate the SAS protocol address of the target disk into a second field, where the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields.

Further, the second transceiver unit 1304 is further configured to receive an Ethernet response packet for the Ethernet operation request packet that is sent by the disk enclosure 102, where the Ethernet response packet for the Ethernet operation request packet carries the MAC address of the back-end adapter 1014. Further, the encapsulating and decapsulating unit 1303 is further configured to decapsulate the Ethernet response packet for the Ethernet operation request packet, to obtain a SCSI protocol operation request response. The first transceiver unit 1301 is further configured to send the SCSI protocol operation request response to the central processing unit 1012. Further, the back-end adapter 1014 further includes a recording unit 1304 that is configured to record a transaction execution state of the SCSI protocol operation request. Specifically, when the Ethernet operation request packet is sent to the disk enclosure 102, the recording unit 1304 records the transaction execution state

CLAIMS

~~What is claimed is:~~

1. A storage system for processing an operation request, wherein the storage system comprises a controller and a disk enclosure, and the controller communicates with the disk enclosure by using an Ethernet network; the controller comprises a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control, MAC, address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface, SAS, protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure;

the back-end adapter is configured to: receive a Small Computer System Interface, SCSI, protocol operation request sent by the central processing unit, wherein the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk; query a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk according to the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure; encapsulate the SCSI protocol operation request into an Ethernet operation request packet; and send the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure, wherein the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure; and

the disk enclosure is configured to: receive and decapsulate the Ethernet operation request packet, to obtain the SCSI protocol operation request; and send the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

2. The system according to claim 1, wherein the disk enclosure is further configured to establish a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller;

the disk enclosure is further configured to: receive a SCSI protocol operation request

to record a transaction execution state of the SCSI protocol operation request; specifically, when sending the Ethernet operation request packet to the disk enclosure, the back-end adapter records the transaction execution state of the SCSI protocol operation request as establishing a link with a SCSI protocol transaction of the target disk and executing the SCSI protocol transaction.

5. The system according to claim 4, wherein the back-end adapter is further configured to update, according to the SCSI protocol operation request response, the transaction execution state of the SCSI protocol operation request to be that the execution of the SCSI protocol transaction is complete and the link with the SCSI protocol transaction of the target disk is released.

6. The system according to claim 4, wherein when the Ethernet operation request response packet does not carry the SCSI protocol transaction identifier of the controller, the back-end adapter is further configured to discard the SCSI protocol operation request response.

7. The system according to claim 1, wherein the correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk is established by the back-end adapter according to resource information sent by the disk enclosure, and the resource information comprises the MAC address of the disk enclosure and the SAS protocol address of the target disk.

8. A method for processing an operation request, wherein the method is applied to a controller, and the controller communicates with a disk enclosure by using an Ethernet network; the controller comprises a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control, MAC, address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface, SAS, protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure; and

the method comprises:

sending, by the central processing unit, a Small Computer System Interface, SCSI, protocol operation request, wherein the SCSI protocol operation request carries a SAS

transaction execution state of the SCSI protocol operation request to be that the execution of the SCSI protocol transaction is complete and the link with the SCSI protocol transaction of the target disk is released.

13. The method according to claim 11, wherein when the Ethernet response packet for the Ethernet operation request packet does not carry the SCSI protocol transaction identifier of the controller, the SCSI protocol operation request response is discarded.

14. The method according to claim 8, wherein the correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk is established by the back-end adapter according to resource information sent by the disk enclosure, and the resource information comprises the MAC address of the disk enclosure and the SAS protocol address of the target disk.

15. A method for processing an operation request, wherein the method is applied to a disk enclosure, and a controller communicates with the disk enclosure by using an Ethernet network; the controller comprises a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control, MAC, address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface, SAS, protocol; and

the method comprises:

receiving and decapsulating, by the disk enclosure, an Ethernet operation request packet sent by the controller, to obtain a Small Computer System Interface, SCSI, protocol operation request, wherein the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure, and the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk; and

sending, by the disk enclosure, the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

16. The method according to claim 15, wherein the method further comprises: establishing, by the disk enclosure, a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller;

receiving, by the disk enclosure, a SCSI protocol operation request response that is sent by the target disk according to the SCSI protocol operation request, wherein the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller;

querying, by the disk enclosure, the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller according to the SCSI protocol transaction identifier of the controller, to obtain the MAC address of the back-end adapter;

encapsulating, by the disk enclosure, the SCSI protocol operation request response into an Ethernet operation request response packet, wherein the Ethernet operation request response packet carries the MAC address of the back-end adapter; and

sending, by the disk enclosure, the Ethernet operation request response packet to the controller according to the MAC address of the back-end adapter.

17. The method according to claim 16, wherein a first field of the Ethernet operation request packet carries the SCSI protocol transaction identifier of the controller, and a second field of the Ethernet operation request packet carries the SAS protocol address of the target disk, wherein the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields;

the establishing, by the disk enclosure, a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller specifically comprises: decapsulating, by the disk enclosure, the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller, and establishing the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and

the sending, by the disk enclosure, the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk specifically comprises: decapsulating, by the disk enclosure, the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk, and sending the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

18. A controller, wherein the controller is applied to a storage system, and the storage

system comprises the controller and a disk enclosure; the controller communicates with the disk enclosure by using an Ethernet network; the controller comprises a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control, MAC, address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface, SAS, protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure;

the central processing unit is configured to send a Small Computer System Interface, SCSI, protocol operation request, wherein the SCSI protocol operation request carries a SAS protocol address of a target disk; and

the back-end adapter is configured to: receive the SCSI protocol operation request; query a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk according to the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure; encapsulate the SCSI protocol operation request into an Ethernet operation request packet; and send the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure, wherein the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure.

19. The controller according to claim 18, wherein the SCSI protocol operation request further carries a SCSI protocol transaction identifier of the controller; and the back-end adapter is further configured to: encapsulate the SCSI protocol transaction identifier of the controller into a first field of the Ethernet operation request packet, and encapsulate the SAS protocol address of the target disk into a second field of the Ethernet operation request packet, wherein the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields.

20. The controller according to claim 19, wherein the back-end adapter is further configured to: receive and decapsulate an Ethernet response packet for the Ethernet operation request packet that is sent by the disk enclosure, to obtain a SCSI protocol operation request response; and send the SCSI protocol operation request response to the central processing

communicates with the disk enclosure by using an Ethernet network; and

the disk enclosure comprises:

a first transceiver unit, configured to receive an Ethernet operation request packet sent by the controller, wherein the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure;

an encapsulating and decapsulating unit, configured to decapsulate the Ethernet operation request packet received by the first transceiver unit, to obtain a Small Computer System Interface, SCSI, protocol operation request, wherein the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk; and

a second transceiver unit, configured to send the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

26. The disk enclosure according to claim 25, further comprising an establishing unit and a querying unit, wherein:

the establishing unit is configured to establish a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller;

the second transceiver unit is further configured to receive a SCSI protocol operation request response that is sent by the target disk according to the SCSI protocol operation request, wherein the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller;

the querying unit is configured to query, according to the SCSI protocol transaction identifier of the controller, the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller that is established by the establishing unit, to obtain the MAC address of the back-end adapter;

the encapsulating and decapsulating unit is further configured to encapsulate the SCSI protocol operation request response into an Ethernet operation request response packet, wherein the Ethernet operation request response packet carries the MAC address of the back-end adapter; and

the first transceiver unit is further configured to send the Ethernet operation request response packet to the controller according to the MAC address of the back-end adapter.

27. The disk enclosure according to claim 26, wherein a first field of the Ethernet operation request packet carries the SCSI protocol transaction identifier of the controller, and a second field of the Ethernet operation request packet carries the SAS protocol address of the target disk, wherein the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields;

that the establishing unit establishes a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller specifically comprises: the encapsulating and decapsulating unit decapsulates the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller, and the establishing unit establishes the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and

that the second transceiver unit sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk specifically comprises: the encapsulating and decapsulating unit decapsulates the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk, and the second transceiver unit sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

28. A back-end adapter, wherein the back-end adapter is applied to a controller of a storage system, the storage system comprises the controller and a disk enclosure, and the controller communicates with the disk enclosure by using an Ethernet network; the controller comprises a central processing unit and the back-end adapter; the disk enclosure and the back-end adapter each have a media access control, MAC, address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface, SAS, protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure; and

the back-end adapter comprises:

a first transceiver unit, configured to send a Small Computer System Interface, SCSI, protocol operation request, wherein the SCSI protocol operation request carries a SAS protocol address of a target disk;

disk and executing the SCSI protocol transaction.

32. The back-end adapter according to claim 31, wherein the recording unit is further configured to update, according to the SCSI protocol operation request response, the transaction execution state of the SCSI protocol operation request to be that the execution of the SCSI protocol transaction is complete and the link with the SCSI protocol transaction of the target disk is released.

33. The back-end adapter according to claim 31, wherein the first transceiver unit is further configured to discard the SCSI protocol operation request response when the Ethernet operation response packet for the Ethernet operation request packet does not carry the SCSI protocol transaction identifier of the controller.

34. The back-end adapter according to claim 29, wherein the correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk is established by the back-end adapter according to resource information sent by the disk enclosure, and the resource information comprises the MAC address of the disk enclosure and the SAS protocol address of the target disk.

~~35. A back-end adapter, wherein the back-end adapter is applied to a controller of a storage system, the storage system comprises the controller and a disk enclosure, and the controller communicates with the disk enclosure by using an Ethernet network; the controller comprises a central processing unit and the back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; the back-end adapter stores a correspondence between the MAC address of the disk enclosure and a SAS protocol address of each disk in the disk enclosure;~~

~~the back-end adapter comprises a first interface, a second interface, a memory, and a first central processing unit, wherein the first interface is configured to receive a Small Computer System Interface SCSI protocol operation request sent by the central processing unit, wherein the SCSI protocol operation request carries a SAS protocol address of a target disk;~~

~~the first central processing unit executes a computer instruction in the memory, to implement the following operations:~~

querying a correspondence between the MAC address of the disk enclosure and the SAS protocol address of the target disk according to the SAS protocol address of the target disk, to obtain the MAC address of the disk enclosure; and encapsulating the SCSI protocol operation request into an Ethernet operation request packet, wherein the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure; and

the second interface is configured to send the Ethernet operation request packet to the disk enclosure according to the MAC address of the disk enclosure.

36. The back-end adapter according to claim 35, wherein the SCSI protocol operation request further carries a SCSI protocol transaction identifier of the controller; and the first central processing unit executes the computer instruction in the memory, and further implements the following operations:

encapsulating the SCSI protocol transaction identifier of the controller into a first field of the Ethernet operation request packet, and encapsulating the SAS protocol address of the target disk into a second field, wherein the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields.

37. The back-end adapter according to claim 36, wherein the second interface is further configured to receive an Ethernet response packet for the Ethernet operation request packet that is sent by the disk enclosure, wherein the Ethernet response packet for the Ethernet operation request packet carries the MAC address of the back-end adapter;

the first central processing unit executes the computer instruction in the memory, and is further configured to implement the following operation:

decapsulating the Ethernet response packet for the Ethernet operation request packet, to obtain a SCSI protocol operation request response; and

the first interface is further configured to send the SCSI protocol operation request response to the central processing unit.

38. The back-end adapter according to claim 37, wherein the first central processing unit executes the computer instruction in the memory, and is further configured to implement the following operation:

recording a transaction execution state of the SCSI protocol operation request; specifically, when the Ethernet operation request packet is sent to the disk enclosure, recording the transaction execution state of the SCSI protocol operation request as establishing a link with a SCSI protocol transaction of the target disk and executing the SCSI protocol transaction.

39. The back-end adapter according to claim 38, wherein the first central processing unit executes the computer instruction in the memory, and is further configured to implement the following operation:

updating, according to the SCSI protocol operation request response, the transaction execution state of the SCSI protocol operation request to be that the execution of the SCSI protocol transaction is complete and the link with the SCSI protocol transaction of the target disk is released.

40. The back-end adapter according to claim 38, wherein the first central processing unit executes the computer instruction in the memory, and is further configured to implement the following operation:

discarding the SCSI protocol operation request response when the Ethernet response packet for the Ethernet operation request packet does not carry the SCSI protocol transaction identifier of the controller.

41. The back-end adapter according to claim 35, wherein the first interface is a Peripheral Component Interconnect Express PCIe interface.

42. A disk enclosure, wherein the disk enclosure is applied to a storage system, the storage system comprises a controller and the disk enclosure, and the controller communicates with the disk enclosure by using an Ethernet network; the controller comprises a central processing unit and a back-end adapter; the disk enclosure and the back-end adapter each have a media access control MAC address; multiple disks are connected in the disk enclosure, and each disk in the disk enclosure is connected to the disk enclosure by using the Serial Attached Small Computer System Interface SAS protocol; and the disk enclosure comprises: a front-end interface, a back-end interface, a first central processing unit, and a first memory, wherein:

the front-end interface is configured to receive and decapsulate an Ethernet operation

request packet sent by the controller, to obtain a Small Computer System Interface SCSI protocol operation request, and send the SCSI protocol operation request to the first central processing unit, wherein the Ethernet operation request packet carries the MAC address of the back-end adapter and the MAC address of the disk enclosure, and the SCSI protocol operation request carries a SCSI protocol transaction identifier of the controller and a SAS protocol address of a target disk;

the first central processing unit executes a computer instruction in the first memory, to implement the following operations:

receiving the SCSI protocol operation request, and sending the SCSI protocol operation request to the back-end interface; and

the back-end interface is configured to receive the SCSI protocol operation request, and send the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.

43. The disk enclosure according to claim 42, wherein the first central processing unit executes the computer instruction in the first memory, and further implements the following operation:

establishing a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and the back-end interface is configured to according to the SAS protocol address of the target disk;

the back-end interface is further configured to receive a SCSI protocol operation request response that is sent by the target disk according to the SCSI protocol operation request, wherein the SCSI protocol operation request response carries the SCSI protocol transaction identifier of the controller;

the first central processing unit executes the computer instruction in the first memory, and further implements the following operation:

querying the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller according to the SCSI protocol transaction identifier of the controller carried in the SCSI protocol operation request response, to obtain the MAC address of the back-end adapter; and

the front-end interface is further configured to: receive the SCSI protocol operation

request response sent by the first central processing unit; encapsulate the SCSI protocol operation request response into an Ethernet operation request response packet according to the MAC address of the back-end adapter that is obtained by the first central processing unit; and send the Ethernet operation request response packet to the controller according to the MAC address of the back-end adapter, wherein the Ethernet operation request response packet carries the MAC address of the back-end adapter.

44. The disk enclosure according to claim 43, wherein a first field of the Ethernet operation request packet carries the SCSI protocol transaction identifier of the controller, and a second field of the Ethernet operation request packet carries the SAS protocol of the target disk, wherein the first field, the second field, and a field that is in the Ethernet operation request packet and carries the SCSI protocol operation request are three different fields;

the establishing a correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller specifically comprises:

decapsulating, by the front-end interface, the first field of the Ethernet operation request packet, to obtain the SCSI protocol transaction identifier of the controller, and establishing, by an establishing unit of the first central processing unit, the correspondence between the MAC address of the back-end adapter and the SCSI protocol transaction identifier of the controller; and

that the back-end interface sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk specifically comprises: the front-end interface decapsulates the second field of the Ethernet operation request packet, to obtain the SAS protocol address of the target disk, and the back-end interface sends the SCSI protocol operation request to the target disk according to the SAS protocol address of the target disk.