simplified resource pooling-centered interconnect and access protocol (PRAP, Pooled Resource Access Protocol) that can provide high bandwidth and a low delay can meet a requirement of a high-throughput computer data center on low delay.

[0004] In a current method for decoupling a built high-throughput computer, a cloud controller (Cloud Controller) is used as a key module for interconnection, the PRAP interconnect protocol is used to connect a computing pool, a remote storage (memory) resource pool, an input/output (I/O) resource pool, and the like, and a double data rate (DDR, Double Data Rate) interface is used to connect to a central processing unit CPU. However, when data in the remote memory resource pool or input/output resource pool needs to be read, due to a network delay, the cloud controller cannot return required data at the DDR interface within a specified time. Therefore, when a CPU of a high-throughput computer accesses the remote memory resource pool or input/output resource pool by using a network, an interrupt of the CPU is caused, leading to a high access delay and a problem that overall performance of a system is affected because the CPU cannot perform another operation during the interrupt.

SUMMARY

[0005] Embodiments of the present invention provide a computer device and a method for reading/writing data by a computer device, so as to resolve a prior-art problem that system performance is affected because a high delay is caused when a CPU of a computer device reads/writes remote data.

[0006] To achieve the foregoing objective, a first aspect of the embodiments of the present invention provides a computer device, including a central processing unit CPU and a cloud controller, where the cloud controller includes a transmission queue module, a response queue module, a double data rate DDR interface, and a network interface, the DDR interface is configured to connect the CPU to the cloud controller, and the network interface is configured to connect the cloud controller to a network device;

the CPU is configured to: after generating a request for performing a read/write operation on the network device, convert the read/write operation request into a control command, and write the control command into the transmission queue module, where the

address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation; or

the read operation information includes a node address and an offset address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation.

[0009] With reference to the first possible implementation or the second 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,

the CPU is further configured to: after writing the read control command into the command transmission queue module, query, in a polling manner, whether the read response message sent by the network device exists in the response command queue module, and when the CPU determines that the read response message sent by the network device exists in the response command queue module and the read response message is a read success response message, read, from the data receiving queue module, the data to be read by means of the read operation.

[0010] With reference to the first possible implementation or the second possible implementation of the first aspect of the embodiments of the present invention, in a fourth possible implementation of the first aspect of the embodiments of the present invention,

the cloud controller is further configured to: determine whether the read response message sent by the network device exists in the response command queue module, and notify the CPU by means of an interrupt when the read response message sent by the network device exists in the response command queue module; and

the CPU is further configured to: receive an interrupt message sent by the cloud controller, obtain the read response message from the response command queue module according to the interrupt message, and when the obtained read response message indicates a read success, read, from the data receiving queue module, the data to be read by means of the read operation.

[0011] With reference to the first aspect of the embodiments of the present invention, in a fifth possible implementation of the first aspect of the embodiments of the present invention,

the read/write operation request is a write operation request;

the transmission queue module includes a command transmission queue module and a data transmission queue module;

the response queue module includes a response command queue module and a data receiving queue module;

the CPU is specifically configured to: convert the write operation request into a write control command, write the write control command into the command transmission queue module, and write, into the data transmission queue module, data to be written by means of the write operation, where the write control command carries write operation information and is used to instruct the cloud controller to write, into the network device according to the write operation information, the data to be written by means of the write operation; and

the cloud controller is specifically configured to: when the write control command in the command transmission queue module is triggered, extract, from the data transmission queue module according to the write operation information in the write control command, the data to be written by means of the write operation, and write, into the network device, the data to be written by means of the write operation; and when receiving a write response message sent by the network device, write the write response message sent by the network device into the response command queue module.

[0012] With reference to the fifth possible implementation of the first aspect of the embodiments of the present invention, in a sixth possible implementation of the first aspect of the embodiments of the present invention,

the write operation information includes an address of the network device, a length of the data to be written by means of the write operation, and an address, in the data transmission queue module, of the data to be written by means of the write operation; or

the write operation information includes a node address and an offset address of the network device, a length of the data to be written by means of the write operation, and an address, in the data transmission queue module, of the data to be written by means of the write operation.

[0013] With reference to the fifth possible implementation or the sixth possible implementation of the first aspect of the embodiments of the present invention, in a seventh possible implementation of the first aspect of the embodiments of the present invention,

the CPU is further configured to: after writing the write control command into the command transmission queue module, query, in a polling manner, whether the write response message sent by the network device exists in the response command queue module, and when the CPU determines that the write response message sent by the network device exists in the response command queue module, obtain the write response message.

[0014] With reference to the fifth possible implementation or the sixth possible implementation of the first aspect of the embodiments of the present invention, in an eighth possible implementation of the first aspect of the embodiments of the present invention,

the cloud controller is further configured to: determine whether the write response message sent by the network device exists in the response command queue module, and notify the CPU by means of an interrupt when the write response message sent by the network device exists in the response command queue module; and

the CPU is further configured to: receive an interrupt message sent by the cloud controller, and obtain the write response message from the response command queue module according to the interrupt message.

[0015] A second aspect of the embodiments of the present invention further provides a method for reading/writing data by a computer device, where the computer device includes a central processing unit CPU, a cloud controller, and a network interface, the CPU is connected to the cloud controller by using a double data rate DDR interface, and the network interface is configured to connect the cloud controller to a network device; and the method includes:

converting, by the CPU, a request for performing a read/write operation on the network device into a control command, and writing the control command into a transmission queue module of the cloud controller, where the control command is used to instruct the cloud controller to perform a read operation or a write operation on the network device, and the control command carries operation information of the read operation or the write operation; and

the read operation information includes an address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation; or

the read operation information includes a node address and an offset address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation.

[0018] With reference to the first possible implementation or the second possible implementation of the second aspect of the embodiments of the present invention, in a third possible implementation of the second aspect of the embodiments of the present invention,

after writing the read control command into the command transmission queue module, querying, by the CPU in a polling manner, whether the read response message sent by the network device exists in the response command queue module, and when the CPU determines that the read response message sent by the network device exists in the response command queue module and the read response message is a read success response message, reading, from the data receiving queue module, the data to be read by means of the read operation.

[0019] With reference to the first possible implementation or the second possible implementation of the second aspect of the embodiments of the present invention, in a fourth possible implementation of the second aspect of the embodiments of the present invention,

determining, by the cloud controller, whether the read response message sent by the network device exists in the response command queue module, and notifying the CPU by means of an interrupt when the read response message sent by the network device exists in the response command queue module; and

receiving, by the CPU, an interrupt message sent by the cloud controller, obtaining the read response message from the response command queue module according to the interrupt message, and when the obtained read response message indicates a read success, reading, from the data receiving queue module, the data to be read by means of the read operation.

transmission queue module, of the data to be written by means of the write operation; or

the write operation information includes a node address and an offset address of the network device, a length of the data to be written by means of the write operation, and an address, in the data transmission queue module, of the data to be written by means of the write operation.

[0022] With reference to the fifth possible implementation or the sixth possible implementation of the second aspect of the embodiments of the present invention, in a seventh possible implementation of the second aspect of the embodiments of the present invention, the method further includes:

after writing the write control command into the command transmission queue module, querying, by the CPU in a polling manner, whether the write response message sent by the network device exists in the response command queue module, and when the CPU determines that the write response message sent by the network device exists in the response command queue module, obtaining the write response message.

[0023] With reference to the fifth possible implementation or the sixth possible implementation of the second aspect of the embodiments of the present invention, in an eighth possible implementation of the second aspect of the embodiments of the present invention, the method further includes:

determining, by the cloud controller, whether the write response message sent by the network device exists in the response command queue module, and notifying the CPU by means of an interrupt when the write response message sent by the network device exists in the response command queue module; and

receiving, by the CPU, an interrupt message sent by the cloud controller, and obtaining the write response message from the response command queue module according to the interrupt message.

[0024] According to the computer device and the method for reading/writing data by a computer device that are provided in the embodiments of the present invention, a CPU of the computer device is connected to a cloud controller by using a DDR interface, and an interrupt is avoided because the DDR interface has a high data transmission rate. In addition, the CPU converts a read/write operation request into a control command and writes the

control command into a transmission queue module of the cloud controller. Because the cloud controller performs a read operation or a write operation on a network device according to operation information in the control command, after writing the control command into the transmission queue module, the CPU does not need to wait for an operation performed by the cloud controller and can continue to perform other service processing, for example, continue to write another control command. This avoids a waste of CPU resources, and improves CPU utilization and overall performance of a system.

BRIEF DESCRIPTION OF DRAWINGS

[0025] 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.

[0026] FIG. 1 is a schematic architecture diagram of a specific implementation of a high-throughput computer data center in the prior art;

[0027] FIG. 2 is a schematic structural diagram of a computer device according to an embodiment of the present invention;

[0028] FIG. 3 is a schematic structural diagram of a specific implementation of a computer device according to an embodiment of the present invention;

[0029] FIG. 4 is a schematic structural diagram of reading/writing remote data by a computer device according to an embodiment of the present invention; and

[0030] FIG. 5 is a schematic flowchart of a method for reading/writing data by a computer device according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0031] 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 a part rather than 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.

[0032] FIG. 1 is a schematic architecture diagram of a specific implementation of a high-throughput computer data center in the prior art. A computer device includes a central processing unit, a memory, and a cloud controller. The cloud controller is connected to a remote resource pool by using a network. The remote resource pool includes storage resources, input/output resources, or the like. The storage resources, for example, a dynamic random access memory (DRAM, Dynamic Random Access Memory) and a non-volatile memory (NVM, Non-Volatile Memory), form a storage resource pool. The input/output resources, for example, a network adapter and a Peripheral Component Interconnect Express PCIe interface, form an input/output resource pool. It should be noted that FIG. 1 shows merely an example of a structural diagram of a high-throughput computer data center. During specific implementation, another hardware resource (for example, a bus), another resource pool (for example, a computing resource pool), or the like may be further included. In addition, in a computer device, multiple central processing units and multiple memories may form a computing resource pool or the like. Moreover, a quantity of resources in the resource pool shown in FIG. 1 is used as an example. During specific implementation, at least two resources may be included, for example, a memory resource pool may include at least two memories.

[0033] In the example shown in FIG. 1, in addition to a local memory (for example, a dynamic random access memory DRAM using a DDR interface), a CPU in the computer device also has a remote storage space allocated by a system. Each physical storage space is mapped to a global address space. A mapping relationship of the address space is stored in a driver of a cloud controller corresponding to each CPU. For example, a CPU 1 has a 10 GB

local memory and a 100 GB remote storage resource (that is, storage spaces in the storage resource pool that are connected by using a network and can be accessed) in total. Assuming that the CPU 1 can access a remote storage resource pool including a storage space A and a storage space B, and the storage space A and the storage space B each are a storage resource with a capacity of 50 GB, the CPU 1 can access a 110 GB storage space in total: a storage space of 0 to 10 GB in the local memory and a storage space of 10 GB to 110 GB in the remote storage resource pool.

[0034] When the CPU 1 accesses the local memory, data can be accessed within a specified time because network transmission is not required. However, when data is not in the local memory, but in the remote storage resource pool, for example, in the storage space A or the storage space B, a cloud controller 1 can read the data only by accessing the remote storage resource pool by using a network. Because network transmission is required, the cloud controller 1 cannot return the required data to the CPU 1 at a DDR interface within a specified time. Therefore, after receiving a data read request delivered by the CPU 1, the cloud controller 1 packs the request, sends the request to the storage resource pool by using the network, to obtain data, and returns an ECC error or a PAGE error to the CPU 1. When receiving error information sent by the cloud controller 1, the CPU 1 interrupts current memory access and suspends a corresponding access thread. After receiving the data sent from the storage resource pool, the cloud controller 1 generates an interrupt signal to notify the CPU 1. The CPU 1 can obtain, according to the received interrupt signal and only by resending a memory reading request, the data that needs to be read. Because the data has been written into a storage space of the cloud controller 1 at this time, the CPU 1 can obtain the data at the DDR interface within a specified time. Therefore, when data that needs to be accessed by the CPU 1 is not inside the cloud controller 1, the CPU 1 needs to perform one interrupt operation and two read operations. As a result, a high access delay is caused, and overall performance of a system is affected because the CPU 1 cannot perform another operation during the interruption.

[0035] To resolve problems of an excessively high access delay and low system performance that are caused by a network delay when a CPU in the foregoing high-throughput computer data center accesses data that is not in a local resource, an

embodiment of the present invention provides a computer device 10. As shown in FIG. 2, the computer device 10 includes a central processing unit CPU 100 and a cloud controller 200. The cloud controller 200 includes a transmission queue module 201, a response queue module 202, a double data rate DDR interface 203, and a network interface 204. The DDR interface 203 is configured to connect the CPU 100 to the cloud controller 200, and the network interface 204 is configured to connect the cloud controller 200 to a network device.

[0036] The CPU 100 is configured to: after generating a request for performing a read/write operation on the network device, convert the read/write operation request into a control command, and write the control command into the transmission queue module 201. The control command is used to instruct the cloud controller 200 to perform a read operation or a write operation on the network device, and the control command carries operation information of the read operation or the write operation.

[0037] The cloud controller 200 is configured to: when the control command in the transmission queue module 201 is triggered, perform the read operation or the write operation on the network device according to the operation information in the control command, receive a response message sent by the network device, and write the response message sent by the network device into the response queue module 202.

[0038] In this embodiment of the present invention, the network device connected to the computer device 10 by using the network interface 204 is a device connected to the computer device 10 by using a network. When the CPU 100 needs to access data in the network device, the cloud controller 200 needs to send a data read/write message to the network device by using the network, and receives a response message or data returned by the network device by using the network. The CPU 100 is connected to the cloud controller 200 by using the DDR interface 203, and an interrupt is avoided because the DDR interface 203 has a high data transmission rate. In addition, the CPU 100 converts a read/write operation request into a control command and writes the control command into the transmission queue module 201 of the cloud controller 200. Because the cloud controller 200 performs the read operation or the write operation on the network device according to operation information in the control command, after writing the control command into the transmission queue module 201, the CPU 100 does not need to wait for an operation performed by the cloud controller 200, and

of the read operation, and sending the communications packet to the network device by using a network; or creating, by the cloud controller 200, a communications packet by using the node address and the offset address, in the network device, of the data to be read by means of the read operation and the length of the data to be read by means of the read operation, and sending the communications packet to the network device by using a network. Specifically, the communications packet may be a PRAP data packet.

[0045] After converting the read operation request into the read control command and writing the read control command into the command transmission queue module 2011, the CPU 100 may perform another operation, for example, continue to write another read control command or write control command. The cloud controller 200 may extract the read control command from the command transmission queue module 2011 when the read control command is written into the command transmission queue module 2011, execute the read control command, write a result of executing the read control command into the response command queue module 2021, and when obtaining data that is read, write the read data into the data receiving queue module 2022. In this way, a read operation request is converted into two processes of writing a read control command by the CPU 100 and executing the read control command by the cloud controller 200. The CPU 100 can execute another task with no need to wait for a result of performing a read operation by the cloud controller 200, and only needs to obtain a read operation result when a read operation response command is written into the response command queue module 2021. This avoids an interrupt caused because the CPU 100 waits for a read operation result for an excessively long time, and improves resource utilization of the CPU 100 and overall performance of a system.

[0046] In this embodiment of the present invention, the CPU 100 may obtain the read operation result by querying in a polling manner or by being notified by means of an interrupt. For example, after writing the read control command into the command transmission queue module, the CPU 100 queries, in a polling manner, whether the read response message sent by the network device exists in the response command queue module 2021, that is, repeatedly queries, according to a preset time interval, whether the read response message sent by the network device exists in the response command queue module 2021. When determining that the read response message sent by the network device exists in the response command queue

the CPU 100 is specifically configured to: convert the write operation request into a write control command, write the write control command into the command transmission queue module 2011, and write, into the data transmission queue module 2012, data to be written by means of the write operation, where the write control command carries write operation information and is used to instruct the cloud controller 200 to write, into the network device according to the write operation information, the data to be written by means of the write operation; and

the cloud controller 200 is specifically configured to: when the write control command in the command transmission queue module 2011 is triggered, extract, from the data transmission queue module 2012 according to the write operation information in the write control command, the data to be written by means of the write operation, and write, into the network device, the data to be written by means of the write operation; and when receiving a write response message sent by the network device, write the write response message sent by the network device into the response command queue module 2021.

[0051] Specifically, the converting the write operation request into a write control command and writing the write control command into the command transmission queue module 2011 is implemented by a driver that runs in the CPU 100.

[0052] That the write control command in the command transmission queue module 2011 is triggered may be that when the write control command is written into the command transmission queue module 2011, the cloud controller is triggered to extract the write control command from the command transmission queue module 2011. During specific implementation, a control unit or a control module of the cloud controller may extract the write control command from the command transmission queue module 2011 when the write control command is written into the command transmission queue module 2011, and execute the read control command.

[0053] In a specific implementation, the write operation information includes an address of the network device, a length of the data to be written by means of the write operation, and an address, in the data transmission queue module, of the data to be written by means of the write operation; or

the write operation information includes a node address and an offset address of

the network device, a length of the data to be written by means of the write operation, and an address, in the data transmission queue module, of the data to be written by means of the write operation.

[0054] Optionally, the extracting, by the cloud controller 200 from the data transmission queue module 2012 according to the write operation information in the write control command, the data to be written by means of the write operation, and writing, into the network device, the data to be written by means of the write operation may include: creating a communications packet by using the data to be written by means of the write operation, the address of the network device, and the length of the data to be written by means of the write operation, and sending the communications packet to the network device by using a network; or creating, by the cloud controller 200, a communications packet by using the data to be written by means of the write operation, the node address and the offset address of the network device, and the length of the data to be written by means of the write operation, and sending the communications packet to the network device by using a network. Specifically, the communications packet may be a PRAP data packet.

[0055] After converting the write operation request into the write control command and writing the write control command into the command transmission queue module 2011, the CPU 100 may perform another operation, for example, continue to write another read control command or write control command. The cloud controller 200 may extract the write control command from the command transmission queue module 2011 when the write control command is written into the command transmission queue module 2011, execute the write control command, and write a result of executing the write control command into the response command queue module 2021. In this way, a write operation request is converted into two processes of writing a write control command into the command transmission queue module 2011 of the cloud controller and executing the write control command by the cloud controller 200. The CPU 100 can execute another task with no need to wait for a result of performing a write operation by the cloud controller 200, and only needs to obtain a write operation result when a write operation response command is written into the response command queue module 2021. This avoids an interrupt caused because the CPU 100 waits

for a write operation result for an excessively long time, and improves resource utilization of the CPU 100 and overall performance of the computer device.

[0056] In this embodiment of the present invention, the CPU 100 may further obtain the write operation result by querying in a polling manner or by being notified by means of an interrupt. For example, after writing the write control command into the command transmission queue module, the CPU 100 queries, in a polling manner, whether the write response message sent by the network device exists in the response command queue module 2021, that is, repeatedly queries, according to a preset time interval, whether the write response message sent by the network device exists in the response command queue module 2021. When determining that the write response message sent by the network device exists in the response command queue module 2021, the CPU 100 obtains the write response message.

[0057] The obtaining the write operation result by being notified by means of an interrupt includes: determining, by the cloud controller 200, whether the write response message sent by the network device exists in the response command queue module 2021, and notifying the CPU 100 by means of an interrupt when the write response message sent by the network device exists in the response command queue module 2021. Specifically, the cloud controller 200 may notify the CPU 100 by means of an interrupt when the write response message is written into the response command queue module 2021. The CPU 100 is further configured to: receive an interrupt message sent by the cloud controller 200, and obtain the write response message from the response command queue module 2021 according to the interrupt message.

[0058] In the foregoing embodiment, the command transmission queue module 2011, the data transmission queue module 2012, the response command queue module 2021, and the data receiving queue module 2022 may be implemented by hardware such as a register or a memory, and are connected to the DDR interface or the like by using a hardware interface. In addition, the command transmission queue module 2011 and the response command queue module 2021 store related commands or messages in an ordered arrangement manner such as in a queue form, and the data transmission queue module 2012 and the data receiving queue module 2022 store related data in an ordered arrangement manner such as in a queue form, so

meet a requirement of quickly obtaining data by the CPU. However, in this embodiment of the present invention, no limitation is imposed on a specific form of an interface used between a CPU and a cloud controller. Another interface that can be used for quickly reading/writing data and that can meet a requirement of quickly reading/writing data by a CPU, for example, an interface whose reading/writing rate is equal to or similar to a reading/writing rate between a CPU and a memory, can be used as an interface between the CPU and the cloud controller.

[0063] The following uses a specific example to describe a schematic structural diagram of a manner of reading/writing remote data by a computer device according to an embodiment of the present invention. As shown in FIG. 4, in addition to a local memory (for example, a DRAM using a DDR interface), a CPU 1 in a CPU resource pool also has remote storage spaces (a storage space A and a storage space B) allocated by a system. Each physical storage space is mapped to a global address space. A mapping relationship of the address space is stored in a driver of a cloud controller corresponding to each CPU. In this embodiment, descriptions are provided by using an example in which the remote storage spaces include only the storage space A and the storage space B. During specific implementation, two or more storage spaces may be included. For example, the CPU 1 has a 10 GB local memory and a 100 GB remote storage resource in total, the CPU 1 can access a remote storage resource pool including the storage space A and the storage space B, and the storage space A and the storage space B each are a storage space with a capacity of 50 GB. In this case, the CPU 1 can access a 110 GB storage space in total: a storage space of 0 to 10 GB in the local memory and a storage space of 10 GB to 110 GB in the remote storage resource pool.

[0064] When the CPU 1 accesses the local memory, if an address space of 0 GB to 10 GB is accessed, the address space is mapped to the local memory, and the local memory is accessed by using the DDR interface.

[0065] When the CPU 1 accesses an address space of 10 GB to 110 GB, for example, 1 MB data needs to be written into the address space of 10 GB to 110 GB, the following steps are included:

[0066] Step 1. A driver of the CPU 1 first writes, into a data transmission queue module of a cloud controller 1, the 1 MB data that needs to be written. It is assumed that the data is stored in an address of 5 KB in the data transmission queue module.

[0067] Step 2. The driver of the CPU 1 obtains an address, in the storage resource pool, into which the 1 MB data to be written. Assuming that the address is the 100th GB address, the address is mapped to an address of 40 GB in the storage space B. Because an address range mapped to the storage space A is 10 GB to 60 GB, an address range mapped to the storage space B is 60 GB to 110 GB.

[0068] Step 3. The driver of the CPU 1 writes, into a command transmission queue module of the cloud controller 1, address information of the remote storage space B, an offset address of 40 GB of the storage space B, an address of 5 KB in a data transmission queue, information of a data length of 1 MB, an identifier ID (for example, 0x01) of a current command, and other information. The driver of the CPU 1 may write the command into the command transmission queue module of the cloud controller 1 by writing the command into a particular register.

[0069] Step 4. The cloud controller 1 obtains a new command (that is, the command of writing 1 MB data) from the command transmission queue module after finding that the command transmission queue module is not empty, parses the command to obtain the address of the remote storage space B, the offset address of the storage space B, the command identifier ID, and the data length, and other information, obtains corresponding data from the data transmission queue module according to the address, in the data transmission queue module, of the 1 MB data in the command transmission queue module to create a communications packet, and sends the communications packet to the storage space B by using a network. In this case, if the CPU 1 needs to further perform another write operation, the driver of the CPU 1 may repeatedly perform the foregoing steps, and continue to write corresponding data and a corresponding command into the cloud controller 1.

[0070] Step 5. After the 1 MB data is written into the storage space B, return a packet (carrying the corresponding command identifier ID: 0x01) indicating that data writing is complete. After the cloud controller 1 of the CPU 1 receives the returned packet, the cloud controller 1 of the CPU 1 writes information that a write command is complete into the

response command queue module. The driver of the CPU 1 obtains, by querying the response command queue module, a write complete operation in which an identifier is 0x01, or the response command queue module notifies, by means of an interrupt, the CPU 1 that the write complete operation in which an identifier is 0x01 has been received, and the CPU 1 learns that the write operation of writing 1 MB data in the 100th GB address is complete.

[0071] When the CPU 1 accesses an address space of 10 GB to 110 GB, for example, 1 MB data needs to be read from the address space of 10 GB to 110 GB, the following steps are included:

[0072] Step 1. The driver of the CPU 1 obtains an address of to-be-read data in the storage resource pool. Assuming that the address is an address of 100 GB, the address is mapped to an address of 40 GB on a node B.

[0073] Step 2. The driver of the CPU 1 writes, into the command transmission queue module of the cloud controller 1, address information of the storage space B, an offset address of 40 GB of the to-be-read data in the storage space B, information of a data length of 1 MB, an identifier ID (for example, 0x02) of a current command, and other information. The driver of the CPU 1 may write, by writing a command of reading the 1 MB data into a particular register, the command of reading the 1 MB data into the command transmission queue module of the cloud controller 1.

[0074] Step 3. After finding that a command transmission queue is not empty, the cloud controller 1 obtains, from the command transmission queue module, the command of reading the 1 MB data, parses the command to obtain the address information of the remote storage space B, the offset address of the 1 MB data in the storage space B, the command identifier ID, the data length, and other information to create a communications packet, and sends the communications packet to the storage space B by using a network. If the CPU 1 needs to further perform another read or write operation, the CPU 1 may repeatedly perform the foregoing steps, but different command identifiers need to be used to represent different commands.

[0075] Step 4. After reading the corresponding data from the remote storage space B, the cloud controller 1 stores the returned data in the data receiving queue module, and writes, into

response message sent by the network device, writing the read response message sent by the network device into the response command queue module of the response queue module, and writing, into the data receiving queue module of the response queue module, data that is to be read by means of the read operation and that is returned by the network device.

[0083] The read operation information may include an address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation; or the read operation information includes a node address and an offset address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation.

[0084] After converting the read operation request into the read control command and writing the read control command into the command transmission queue module, the CPU may perform another operation, for example, continue to write another read control command or write control command. The cloud controller may extract the read control command from the command transmission queue module when the read control command is written into the command transmission queue module, execute the read control command, write a result of executing the read control command into the response command queue module, and write read data into the data receiving queue module when obtaining the read data. In this way, a read operation request is converted into two processes of writing a read control command by a CPU and executing the read control command by the cloud controller. The CPU can execute another task with no need to wait for a result of performing a read operation by the cloud controller, and only needs to obtain a read operation result when a read operation response command is written into the response command queue module. This avoids an interrupt caused because the CPU waits for a read operation result for an excessively long time, and improves resource utilization of the CPU.

[0085] Further, in this embodiment of the present invention, the CPU may obtain the read operation result by querying in a polling manner or by being notified by means of an interrupt.

[0086] When obtaining the read operation result by querying in a polling manner, the CPU queries, in a polling manner, after writing the read control command into the command transmission queue module, whether the read response message sent by the network device

[0091] Further, in this embodiment of the present invention, the CPU may obtain the write operation result by querying in a polling manner or by being notified by means of an interrupt.

[0092] When obtaining the write operation result by querying in a polling manner, the CPU queries, in a polling manner, after writing the write control command into the command transmission queue module, whether the write response message sent by the network device exists in the response command queue module, and the CPU obtains the write response message when determining that the write response message sent by the network device exists in the response command queue module.

[0093] When obtaining the write operation result by being notified by means of an interrupt, the cloud controller determines whether the write response message sent by the network device exists in the response command queue module, and notifies the CPU by means of an interrupt when the write response message sent by the network device exists in the response command queue module. The CPU receives an interrupt message sent by the cloud controller, and obtains the write response message from the response command queue module according to the interrupt message.

[0094] The implementation of the foregoing method embodiment may also be implemented with reference to the implementations of the computer device 10, and no details are repeated.

[0095] A person of ordinary skill in the art may be aware that, in combination with the examples described in the embodiments disclosed in this specification, units and algorithm steps may be implemented by electronic hardware, computer software, or a combination thereof. To clearly describe the interchangeability between the hardware and the software, the foregoing has generally described compositions and steps of each example according to functions. Whether the functions are performed by hardware or software depends on particular applications and design constraint conditions of the technical solutions. A person skilled in the art may use different methods to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of the present invention.

CLAIMS:

1. A computer device (10), comprising:

a central processing unit, CPU (100), and a cloud controller (200), wherein the cloud controller (200) comprises a transmission queue module (201), a response queue module (202), a double data rate, DDR, interface (203), and a network interface (204), the DDR interface (203) is configured to connect the CPU (100) to the cloud controller (200), and the network interface (204) is configured to connect the cloud
controller (200) to a network device;

the CPU (100) is configured to: after generating a request for performing a read/write operation on the network device (204), convert the read/write operation request into a control command, and write the control command into the transmission queue module (201), wherein the control command is used to instruct the cloud controller (200) to perform a read operation or a write operation on the network device, and the control command carries operation information of the read operation or the write operation; and

the cloud controller (200) is configured to: when the control command in the transmission queue module (201) is triggered, perform the read operation or the write operation on the network device according to the operation information in the control command, receive a response message sent by the network device, and write the response message sent by the network device into the response queue module (202).

2. The computer device (10) according to claim 1, wherein the read/write operation request is a read operation request;

the transmission queue module (201) comprises a command transmission queue module (2011) and a data transmission queue module (2012);

the response queue module (2022) comprises a response command queue module (2021) and a data receiving queue module (2022);

the CPU (100) is specifically configured to: convert the read operation request into a read control command, and write the read control command into the command transmission queue module (2011), wherein the read control command carries read operation information and is used to instruct the cloud controller to perform a read operation on the network device according to the read operation information; and

the cloud controller (200) is specifically configured to: when the read control command in the command transmission queue module (2011) is triggered, perform the read

operation on the network device according to the read operation information in the read control command, receive a read response message sent by the network device, write the read response message sent by the network device into the response command queue module (2021), and write, into the data receiving queue module (2022), data that is to be read by means of the read operation and that is returned by the network device.

3. The computer device (10) according to claim 2, wherein the read operation information comprises an address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation; or

the read operation information comprises a node address and an offset address, in the network device, of the data to be read by means of the read operation and a length of the data to be read by means of the read operation.

4. The computer device (10) according to claim 2 or 3, wherein the CPU (100) is further configured to: after writing the read control command into the command transmission queue module (2011), query, in a polling manner, whether the read response message sent by the network device exists in the response command queue module (2021), and when the CPU (100) determines that the read response message sent by the network device exists in the response command queue module (2021) and the read response message is a read success response message, read, from the data receiving queue module (2022), the data to be read by means of the read operation.

5. The computer device (10) according to claim 2 or 3, wherein the cloud controller (200) is further configured to: determine whether the read response message sent by the network device exists in the response command queue module (2021), and notify the CPU (100) by means of an interrupt when the read response message sent by the network device exists in the response command queue module (2021); and

the CPU (100) is further configured to: receive an interrupt message sent by the cloud controller (200), obtain the read response message from the response command queue module (2021) according to the interrupt message, and when the obtained read response message indicates a read success, read, from the data receiving queue module (2022), the data to be read by means of the read operation.

6. The computer device (10) according to claim 1, wherein the read/write operation request is a write operation request;

the transmission queue module (201) comprises a command transmission queue module (2011) and a data transmission queue module (2012);

the response queue module (202) comprises a response command queue module (2021) and a data receiving queue module (2022);

the CPU (100) is specifically configured to: convert the write operation request into a write control command, write the write control command into the command transmission queue module (2011), and write, into the data transmission queue module (2012), data to be written by means of the write operation, wherein the write control command carries write operation information and is used to instruct the cloud controller (200) to write, into the network device according to the write operation information, the data to be written by means of the write operation; and

the cloud controller (200) is specifically configured to: when the write control command in the command transmission queue module (2011) is triggered, extract, from the data transmission queue module (2012) according to the write operation information in the write control command, the data to be written by means of the write operation, and write, into the network device, the data to be written by means of the write operation; and when receiving a write response message sent by the network device, write the write response message sent by the network device into the response command queue module (2021).

7. The computer device (10) according to claim 6, wherein the write operation information comprises an address of the network device, a length of the data to be written by means of the write operation, and an address, in the data transmission queue module (2012), of the data to be written by means of the write operation; or

the write operation information comprises a node address and an offset address of the network device, a length of the data to be written by means of the write operation, and an address, in the data transmission queue module (2012), of the data to be written by means of the write operation.

8. The computer device (10) according to claim 6 or 7, wherein the CPU (100) is further configured to: after writing the write control command into the command transmission queue module (2011), query, in a polling manner, whether the write response message sent by the network device exists in the response command queue module (2021), and when the CPU

(100) determines that the write response message sent by the network device exists in the response command queue module (2021), obtain the write response message.

9. The computer device (10) according to claim 6 or 7, wherein the cloud controller (200) is further configured to: determine whether the write response message sent by the network device exists in the response command queue module (2021), and notify the CPU (100) by means of an interrupt when the write response message sent by the network device exists in the response command queue module (2021); and

the CPU (100) is further configured to: receive an interrupt message sent by the cloud controller (200), and obtain the write response message from the response command queue module (2021) according to the interrupt message.

10. A method for reading/writing data by a computer device, wherein the computer device comprises a central processing unit, CPU, a cloud controller, and a network interface, the CPU is connected to the cloud controller by using a double data rate, DDR, interface, and the network interface is configured to connect the cloud controller to a network device; and the method comprises:

converting (500), by the CPU, a request for performing a read/write operation on the network device into a control command, and writing the control command into a transmission queue module of the cloud controller, wherein the control command is used to instruct the cloud controller to perform a read operation or a write operation on the network device, and the control command carries operation information of the read operation or the write operation; and

performing (502), by the cloud controller, the read operation or the write operation on the network device according to the operation information in the control command when the control command in the transmission queue module is triggered, and writing a response message sent by the network device into a response queue module of the cloud controller when receiving the response message sent by the network device.

11. The method according to claim 10, wherein the read/write operation request is a read operation request;

correspondingly, converting, by the CPU, a request for performing a read/write operation on the network device into a control command, and writing the control command into a transmission queue module of the cloud controller comprises:

converting, by the CPU, the read operation request into a read control command, and writing the read control command into a command transmission queue module of the transmission queue module, wherein the read control command carries read operation information and is used to instruct the cloud controller to perform a read operation on the network device according to the read operation information; and

performing, by the cloud controller, the read operation or the write operation on the network device according to the operation information in the control command, and writing a response message sent by the network device into a response queue module of the cloud controller when receiving the response message sent by the network device comprises:

performing, by the cloud controller, the read operation on the network device according to the read operation information in the read control command when the read control command in the command transmission queue module is triggered, receiving a read response message sent by the network device, writing the read response message sent by the network device into the response command queue module of the response queue module, and writing, into the data receiving queue module of the response queue module, data that is to be read by means of the read operation and that is returned by the network device.

12. The method according to claim 11, wherein the method further comprises:

after writing the read control command into the command transmission queue module, querying, by the CPU in a polling manner, whether the read response message sent by the network device exists in the response command queue module, and when the CPU determines that the read response message sent by the network device exists in the response command queue module and the read response message is a read success response message, reading, from the data receiving queue module, the data to be read by means of the read operation.

13. The method according to claim 11, wherein the method further comprises:

determining, by the cloud controller, whether the read response message sent by the network device exists in the response command queue module, and notifying the CPU by means of an interrupt when the read response message sent by the network device exists in the response command queue module; and

receiving, by the CPU, an interrupt message sent by the cloud controller, obtaining the read response message from the response command queue module according to the interrupt

message, and when the obtained read response message indicates a read success, reading, from the data receiving queue module, the data to be read by means of the read operation.

14. The method according to claim 10, wherein the read/write operation request is a write operation request;

correspondingly, converting, by the CPU, a request for performing a read/write operation on the network device into a control command, and writing the control command into a transmission queue module of the cloud controller comprises:

converting, by the CPU, the write operation request into a write control command, writing the write control command into the command transmission queue module of the transmission queue module, and writing, into the data transmission queue module of the transmission queue module, data to be written by means of the write operation, wherein the write control command carries write operation information and is used to instruct the cloud controller to write, into the network device according to the write operation information, the data to be written by means of the write operation; and

performing, by the cloud controller, the read operation or the write operation on the network device according to the operation information in the control command, and writing a response message sent by the network device into a response queue module of the cloud controller when receiving the response message sent by the network device comprises:

when the write control command in the command transmission queue module is triggered, extracting, by the cloud controller from the data transmission queue module according to the write operation information in the write control command, the data to be written by means of the write operation, and writing, into the network device, the data to be written by means of the write operation; and when receiving a write response message sent by the network device, writing the write response message sent by the network device into the response command queue module of the response queue module.

15. The method according to claim 14, wherein the method further comprises:

determining, by the cloud controller, whether the write response message sent by the network device exists in the response command queue module, and notifying the CPU by means of an interrupt when the write response message sent by the network device exists in the response command queue module; and

receiving, by the CPU, an interrupt message sent by the cloud controller, and obtaining the write response message from the response command queue module according to the interrupt message.