# VIRTUAL MACHINE MIGRATION METHOD, DEVICE, AND STORAGE MEDIUM

**[0001]** The present disclosure claims priority to Chinese Patent Application No. 202311256023.4, filed with the China National Intellectual Property Administration on September 26, 2023, and entitled "VIRTUAL MACHINE MIGRATION METHOD, DEVICE, AND STORAGE MEDIUM", which is incorporated herein by reference in its entirety.

## TECHNICAL FIELD

**[0002]** The present disclosure relates to the field of internet technologies, and in particular, to a virtual machine migration method, a device, and a storage medium.

## BACKGROUND

**[0003]** Local storage resources refer to storage resources such as hard disks built in physical servers. Virtual machines using local storage resources usually carry storage-intensive tasks, to be specific, tasks in which a large quantity of read and write operations need to be performed on local storage. Therefore, such virtual machines usually have a considerable amount of locally stored data.

**[0004]** When cold migration is performed on such virtual machines, migration of the locally stored data usually takes a long time, resulting in excessively long downtime of the virtual machines. This causes various tasks carried on the virtual machines to be interrupted for a long time.

## SUMMARY

**[0005]** A plurality of aspects of the present disclosure provide a virtual machine migration method, a device, and a storage medium, to reduce downtime of a virtual machine in a migration process.

**[0006]** An embodiment of the present disclosure provides a virtual machine migration method, including:

allocating reserved resources to a target virtual machine from a migration destination

end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at a migration source end;

triggering copying locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources during running of the target virtual machine at the migration source end;

if a copying progress of the locally stored data reaches a specified standard, controlling the target virtual machine to be shut down and then triggering copying remaining locally stored data corresponding to the target virtual machine into the reserved resources; and

switching the target virtual machine to being bound to the reserved resources, and migrating the target virtual machine to the reserved resources.

**[0007]** An embodiment of the present disclosure further provides a management and control apparatus, including:

a resource reservation service module, configured to allocate reserved resources to a target virtual machine from a migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at a migration source end;

a locally stored data migration module, configured to: trigger copying locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources during running of the target virtual machine at the migration source end; and if a copying progress of the locally stored data reaches a specified standard, control the target virtual machine to be shut down and then trigger copying remaining locally stored data corresponding to the target virtual machine into the reserved resources; and

a virtual machine migration module, configured to: during downtime of the target virtual machine, switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources.

**[0008]** An embodiment of the present disclosure further provides a management and control device, including a memory and a processor, where

the memory is configured to store one or more computer instructions; and

the processor is coupled to the memory and is configured to execute the one or more computer instructions, to execute the foregoing virtual machine migration method.

**[0009]** An embodiment of the present disclosure further provides a virtual machine management and control system, including a management and control device, a migration source end at which a target virtual machine is located, and a migration destination end selected for the target virtual machine, where

the management and control device is configured to: allocate reserved resources to the

target virtual machine from the migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at the migration source end; send a data pre-copying task to the migration source end during running of the target virtual machine at the migration source end; control the target virtual machine to be shut down if a copying progress of locally stored data reaches a specified standard; and after copying of the locally stored data is completed, switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources; and

the migration source end is configured to: execute the data pre-copying task, to trigger copying the locally stored data corresponding to the target virtual machine into the reserved resources; and continue to copy remaining locally stored data corresponding to the target virtual machine into the reserved resources after the target virtual machine is shut down.

**[0010]** An embodiment of the present disclosure further provides a computer-readable storage medium storing computer instructions, where when the computer instructions are executed by one or more processors, the one or more processors are caused to execute the foregoing virtual machine migration method.

**[0011]** In the embodiments of the present disclosure, on the premise that the target virtual machine is kept bound to the resources currently occupied by the target virtual machine at the migration source end, the reserved resources are allocated to the target virtual machine from the migration destination end, so that the target virtual machine can normally run at the migration source end without being interfered with by the reserved resources, and an occupation right to the reserved resources can be obtained without migration. On this basis, the locally stored data corresponding to the target virtual machine at the migration source end can be copied into the reserved resources in the running process of the target virtual machine. In addition, after the copying progress of the locally stored data reaches a specified standard, the target virtual machine can be controlled to be shut down, and the remaining locally stored data corresponding to the target virtual machine can be copied into the reserved resources. In addition, during downtime, the target virtual machine can be switched to being bound to the reserved resources, and the target virtual machine can be migrated to the reserved resources. In this way, both the target virtual machine and the locally stored data thereof can be migrated to the reserved resources, and the time consumed by migration of the locally stored data is independent of the migration execution period of the virtual machine. Therefore, the downtime of the virtual machine in the migration process can be effectively reduced.

## BRIEF DESCRIPTION OF DRAWINGS

**[0012]** The accompanying drawings described herein are used to provide further understanding of the present disclosure and constitute a part of the present disclosure. Exemplary embodiments of the present disclosure and descriptions thereof are used to explain the present disclosure, and do not constitute an improper limitation to the present disclosure. In the accompanying drawings:

FIG. 1 is a schematic logical diagram of a virtual machine migration method according to an exemplary embodiment of the present disclosure;

FIG. 2 is a schematic flowchart of a virtual machine migration method according to an exemplary embodiment of the present disclosure;

FIG. 3 is a schematic flowchart of a virtual machine migration method according to another exemplary embodiment of the present disclosure;

FIG. 4 is a schematic structural diagram of a management and control apparatus according to another exemplary embodiment of the present disclosure;

FIG. 5 is a schematic diagram of working logic of a management and control apparatus according to another exemplary embodiment of the present disclosure; and

FIG. 6 is a schematic structural diagram of a management and control device according to still another exemplary embodiment of the present disclosure.

## DESCRIPTION OF EMBODIMENTS

**[0013]** To make the objectives, technical solutions, and advantages of the present disclosure clearer, the technical solutions of the present disclosure will be described below with reference to specific embodiments of the present disclosure and corresponding accompanying drawings. Apparently, the described embodiments are only a part rather than all of the embodiments of the present disclosure. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present disclosure without creative efforts shall fall within the protection scope of the present disclosure.

**[0014]** Before the technical solutions provided in the embodiments of the present disclosure are introduced, several technical concepts involved in the present disclosure are briefly described.

**[0015]** Local storage resources refer to storage resources such as a hard disk built in a physical server.

**[0016]** Shared cloud storage resources refer to cloud storage resources such as a storage cluster or a cloud storage node. A plurality of physical servers can share and use the cloud storage

resources through a network.

**[0017]** A virtual machine of local storage type may be understood as a virtual machine using the local storage resources for data storage. In other words, this type of virtual machine performs data storage by using the local storage resources such as the hard disk on the physical server on which the virtual machine is located.

**[0018]** A virtual machine of shared cloud storage type may be understood as a virtual machine using the shared cloud storage resources for data storage. In other words, this type of virtual machine performs read and write operations on the shared cloud storage resources through the network, to store data in the shared cloud storage resources.

**[0019]** A basic principle of virtual machine cold migration is that after a virtual machine is shut down, a component, data, and the like that need to be migrated are copied into a migration destination end, and the virtual machine can be restarted only after the copying is completed. In other words, in a migration process of the virtual machine, the virtual machine remains in a shutdown state, and a task carried on the virtual machine is also in a suspended state.

**[0020]** In a research process, it is found that for the virtual machine of shared cloud storage type, it is unnecessary to migrate data stored in the shared cloud storage resources in the migration process. Instead, after the migration is completed, an access pathway to the shared cloud storage resources is re-established for a migrated virtual machine. However, for the virtual machine of local storage type, due to isolation inherent in the local storage resources, physical servers do not have access to local storage resources carried in each other. In this case, after migration of the virtual machine, the migration destination end can no longer access locally stored data at a migration source end. Therefore, when migration is performed on the virtual machine of local storage type, the locally stored data corresponding to the virtual machine of local storage type needs to be migrated.

**[0021]** It is further found that tasks carried on the virtual machine of local storage type are mostly storage-intensive tasks. Therefore, this type of virtual machine usually has a considerable amount of locally stored data. Correspondingly, time required for migrating the locally stored data of this type of virtual machine is also long, usually requiring N days or even longer. As a result, when migration is performed on this type of virtual machine, migration of the locally stored data takes a long time. Correspondingly, downtime of the virtual machine is very long, causing much inconvenience to the tasks carried on the virtual machine.

**[0022]** In view of the foregoing technical trouble, the present disclosure provides an innovative virtual machine migration method, to reduce the downtime of the virtual machine in the migration process when the locally stored data needs to be migrated.

**[0023]** The following describes the technical solutions provided in the embodiments of the

present disclosure in detail with reference to the accompanying drawings.

**[0024]** FIG. 1 is a schematic logical diagram of a virtual machine migration method according to an exemplary embodiment of the present disclosure. FIG. 2 is a schematic flowchart of a virtual machine migration method according to an exemplary embodiment of the present disclosure. Referring to FIG. 1, the method may be executed by a management and control apparatus. The management and control apparatus may be implemented as software, hardware, or a combination of software and hardware, and the management and control apparatus may be integrated in a management and control device. Referring to FIG. 1, the management and control device in this embodiment can communicate with various physical servers and has resource management permission on the physical servers, and virtual machines run on the physical servers. In some exemplary application scenarios, each physical server may be a cloud server. In this scenario, the management and control device may be a cloud management and control system. Correspondingly, in this embodiment, the cloud management and control system is reconstructed, to execute, in the cloud management and control system, the virtual machine migration method provided in this embodiment. It should be understood that in this scenario, a physical implementation form of the management and control device in this embodiment may be a single server, a server cluster, or the like. This is not limited herein. Certainly, in some other exemplary application scenarios, the physical server may alternatively be a non-cloud server, for example, may be a private server in an enterprise private computer room. Correspondingly, the management and control device may be a device configured to manage the physical server in the computer room. It should be noted that the foregoing application scenarios are merely examples, and the application scenarios are not limited in this embodiment.

**[0025]** Still referring to FIG. 1, for ease of description, in this embodiment, a target virtual machine is used as an example to describe the virtual machine migration method. It should be understood that the target virtual machine may be any virtual machine to be migrated. In this embodiment, a physical server in which the target virtual machine is located before migration is described as a migration source end, and a physical server in which the target virtual machine should be located after migration is described as a migration destination end. In this embodiment, both the migration source end and the migration destination end have local storage resources.

**[0026]** Based on this, referring to FIG. 2, the virtual machine migration method provided in this embodiment may include the following steps.

**[0027]** Step 200: Allocate reserved resources to the target virtual machine from the migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at the migration source end.

**[0028]** Step 201: Trigger copying locally stored data corresponding to the target virtual

machine at the migration source end into the reserved resources during running of the target virtual machine at the migration source end.

**[0029]** Step 202: If a copying progress of the locally stored data reaches a specified standard, control the target virtual machine to be shut down and then trigger copying remaining locally stored data corresponding to the target virtual machine into the reserved resources.

**[0030]** Step 203: Switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources.

**[0031]** In this embodiment, as mentioned above, the management and control device has resource management permission on various physical servers. From the perspective of the management and control device, when managing physical resources, resources need to be occupied by the virtual machines. In addition, one virtual machine can only establish a binding relationship with a single determined physical server and occupy physical resources. Otherwise, during running of the virtual machine, the management and control device cannot determine to which physical server a working task on the virtual machine is scheduled, which may cause a fault of the virtual machine. For this reason, in an existing migration solution, the virtual machine needs to be shut down first, and then a binding relationship between the virtual machine and the physical machine needs to be switched to the migration destination end and resources of the physical machine need to be occupied, before migration of the locally stored data can be started. Consequently, time consumed by the migration of the locally stored data has to be within the migration period.

**[0032]** In this embodiment, a resource reservation mechanism is provided to break this technical barrier. The resource reservation mechanism in this embodiment means that in one aspect, the management and control device can keep the target virtual machine bound to the resources currently occupied by the target virtual machine at the migration source end, and in another aspect, the management and control device can allocate the reserved resources to the target virtual machine from the migration destination end. In other words, from the perspective of the management and control device, the resources occupied by the target virtual machine are still resources at the migration source end, and do not change at all. This can ensure that the target virtual machine can normally run at the migration source end. On this premise, the management and control device can further define a part of resources from the migration destination end, and reserve the part of resources for the target virtual machine. Referring to FIG. 2, like the resources currently occupied by the target virtual machine at the migration source end, the reserved resources in this embodiment also include the local storage resources, to carry the locally stored data of the target virtual machine. Certainly, the reserved resources may further include computational resources, network resources, and the like required by the target virtual machine. The types of resources in the reserved resources are not limited herein.

**[0033]** On this basis, through the resource reservation mechanism, the target virtual machine can obtain an occupation right to the reserved resources without migration.

**[0034]** In step 200, an implementation in which the management and control device implements the resource reservation mechanism is not limited, provided that the management and control device can recognize, on a premise that an original resource binding state of the target virtual machine is not changed, that a resource occupying body corresponding to the reserved resources is essentially the target virtual machine. The implementation of the resource reservation mechanism is described in detail below, and details are not described here.

**[0035]** In this way, the target virtual machine can normally run based on the resources currently occupied by the target virtual machine at the migration source end. In other words, the target virtual machine can keep running normally at the migration source end. The target virtual machine is unaware of the reserved resources, and the reserved resources do not interfere with running of the target virtual machine.

**[0036]** Still referring to FIG. 2, in step 201, the locally stored data corresponding to the target virtual machine at the migration source end can be copied into the reserved resources during running of the target virtual machine at the migration source end. It should be understood that, in this case, a migration process of the target virtual machine is not started, and the target virtual machine still runs normally at the migration source end. In other words, in step 201, before the target virtual machine is migrated, the locally stored data corresponding to the target virtual machine can be pre-copied into the reserved resources. Apparently, in step 201, the time consumed by the migration of the locally stored data is independent of the migration period, and in a pre-copying process, the virtual machine does not need to be shut down and can run normally. In this way, no matter how long the time consumed by the migration of the locally stored data is, the downtime within the migration period is not affected.

**[0037]** In this embodiment, to ensure accuracy of the foregoing pre-copying process, the management and control device can initiate a data pre-copying task to the migration source end, and specify a storage address corresponding to the reserved resources in the task. In this way, the migration source end can execute the data pre-copying task through a bypass manner, to accurately copy the locally stored data in the local storage resources corresponding to the target virtual machine into a relevant storage location in the reserved resources. At the migration source end, the target virtual machine is unaware of the data pre-copying task.

**[0038]** In this embodiment, in the pre-copying process of the locally stored data, the target virtual machine is still in a running state. Therefore, dirty page data may continuously emerge. In view of this, in an optional implementation of pre-copying:

all locally stored data may be copied into the reserved resources in an initial round of

copying; and

in a non-initial round of copying, the dirty page data generated by running of the target virtual machine during a previous round of copying may be obtained; and the dirty page data is updated to the reserved resources.

**[0039]** The initial round of copying is a first-round copying operation executed by the migration source end after receiving the foregoing data pre-copying task, and a copying operation executed subsequently is described as a non-initial round of copying operation.

**[0040]** In this optional implementation, the migration source end may report, to the management and control device, description information of the dirty page data generated in the running process of the target virtual machine. The description information of the dirty page data may include, but is not limited to, a location, a data volume, and the like of the dirty page. In this way, the management and control device can accurately know the dirty page data newly generated in each round of copying. In the initial round of copying, full copying needs to be performed on the locally stored data. Besides that, in the non-initial round of copying, only the dirty page data generated by the target virtual machine during the previous round of copying needs to be updated to the reserved resources. Because the data volume of the dirty page data is much less than a total data volume of the locally stored data, only the time consumed by the initial round of copying is relatively long, and the time consumed by the non-initial round of copying is continuously shortened. This is because the time consumed by the non-initial round of copying becomes shorter, and dirty page data generated by the target virtual machine during one round of copying also decreases, which can further shorten the time consumed by a next round of copying.

**[0041]** Considering that the locally stored data cannot be completely copied into the reserved resources through pre-copying of the locally stored data, it is proposed in step 202 that a specified standard may be set. The migration source end is instructed to stop executing the data pre-copying task and the target virtual machine is controlled to be shut down when the copying progress of the locally stored data reaches the specified standard. It may be understood that, the number of rounds of copying that the migration source end needs to execute in a process of executing the data pre-copying task depends on when the copying progress of the locally stored data reaches the specified standard. In an actual application, the number of rounds of copying does not need to be manually intervened.

**[0042]** An exemplary specified standard may be that a data volume of dirty page data generated by the running of the target virtual machine in a latest round of copying is less than a specified threshold. In essence, the exemplary specified standard may also be understood as being used for determining whether time consumed by migration of dirty page data in a next round is less than a specified time threshold. When a data copying speed is known, a quotient of the data

volume of the dirty page data by the data copying speed can be calculated here, and the quotient is used as migration time required for the dirty page data. The specified threshold mentioned in the specified standard may be determined based on downtime that can be accepted by task(s) carried on the target virtual machine. For example, the downtime that can be accepted by the task(s) carried on the target virtual machine is 10 minutes, a time threshold for the time consumed by a next round of migration of dirty page data may be set to 8 minutes, and correspondingly, the specified threshold corresponding to the data volume may be set to 1G. Certainly, this is merely exemplary, and this embodiment is not limited thereto.

**[0043]** Still referring to FIG. 2, after the target virtual machine is shut down, in step 202, copying of the remaining locally stored data corresponding to the target virtual machine into the reserved resources may be triggered. In an actual application, when the target virtual machine is shut down, dirty page data generated by the target virtual machine in memory is automatically stored into local storage resources to which the target virtual machine is bound. Because the target virtual machine is bound to the local storage resources at the migration source end before the target virtual machine is shut down, after the target virtual machine is controlled to be shut down, all dirty page data in the target virtual machine that is not migrated will be stored into the local storage resources at the migration source end. This ensures that, in step 202, after the target virtual machine is shut down, the copying of the remaining locally stored data corresponding to the target virtual machine into the reserved resources can be triggered. Herein, the remaining locally stored data is the dirty page data that has not yet been migrated. In addition, the migration source end may continue to update the remaining dirty page data to the reserved resources based on the storage address that is specified in the data pre-copying task received from the management and control device.

**[0044]** Thus, complete migration of the locally stored data in the target virtual machine can be finished. It may be understood that, only the copying operation of the remaining locally stored data in step 202 occupies the downtime of the target virtual machine, and the pre-copying process in step 201 does not occupy the downtime of the target virtual machine at all. The data volume of the remaining locally stored data is very small, and the target virtual machine is controlled to be shut down only after it is confirmed that the migration time required for the remaining locally stored data can satisfy a downtime threshold that can be tolerated by the task(s) carried on the target virtual machine. Therefore, the remaining locally stored data does not cause the downtime of the target virtual machine to exceed the foregoing downtime threshold.

**[0045]** During the downtime, in addition to that the copying of the remaining locally stored data may continue to be completed, referring to FIG. 2, the target virtual machine may further be switched to being bound to the reserved resources and the target virtual machine may be migrated

to the reserved resources in step 203. It should be understood that there is no rigid sequence between the copying of the remaining locally stored data and the migration of the target virtual machine, and both tasks can proceed concurrently without affecting each other.

**[0046]** In step 203, the target virtual machine may be switched to being bound to the reserved resources. In this way, the target virtual machine will occupy the reserved resources using an identity of the target virtual machine itself, and correspondingly, an occupation right of the target virtual machine to related resources at the migration source end will be released. Based on this, components of the target virtual machine other than the locally stored data can be migrated to the reserved resources. Herein, the target virtual machine may be migrated to the reserved resources through a standard migration solution. The standard migration solution may be roughly described as follows: a complete guest image snapshot may be stored at the migration source end for the target virtual machine, and the guest image snapshot includes related information of the components other than the locally stored data in the target virtual machine; after the target virtual machine is shut down, the guest image snapshot may be copied into the migration destination end (which specifically refers to the reserved resources in this embodiment). It should be understood that, in the process of migrating the target virtual machine to the reserved resources, the locally stored data of the target virtual machine does not need to be considered.

**[0047]** In this way, the migration of the target virtual machine can be completed, and the locally stored data of the target virtual machine is also completely migrated to the migration destination end.

**[0048]** After the migration is completed, the target virtual machine may be controlled to start up, and then the target virtual machine continues to run based on the foregoing reserved resources. It should be understood that after the migration is completed, the foregoing reserved resources essentially become physical resources to which the target virtual machine is bound.

**[0049]** An exemplary startup process may be as follows.

**[0050]** After the migration is completed, the management and control device may send a migration completion notification to a client corresponding to the target virtual machine. After receiving the migration completion notification, the client may initiate a startup request for the target virtual machine. After receiving the startup request, the management and control device may schedule the startup request to the migration destination end corresponding to the target virtual machine. The startup request includes description information of the reserved resources, to control the migration destination end to start up the target virtual machine based on the reserved resources.

**[0051]** It should be understood that the resources to which the target virtual machine is bound are switched to the reserved resources. Therefore, after receiving the startup request for the target virtual machine, when scheduling the startup request, the management and control device may

search for a resource binding relationship that the target virtual machine is in according to a conventional protocol. In this way, the description information of the reserved resources is read from the resource binding relationship, so that the description information of the reserved resources is added to the startup request, instead of description information of resources occupied by the target virtual machine at the migration source end. On this basis, the migration destination end may start up, in response to the startup request, the target virtual machine based on the reserved resources.

**[0052]** In conclusion, in this embodiment, on the premise that the target virtual machine is kept bound to the resources currently occupied by the target virtual machine at the migration source end, the reserved resources are allocated to the target virtual machine from the migration destination end, so that the target virtual machine can normally run at the migration source end without being interfered with by the reserved resources, and the occupation right to the reserved resources can be obtained without migration. On this basis, the locally stored data corresponding to the target virtual machine at the migration source end can be copied into the reserved resources in the running process of the target virtual machine. In addition, after the copying progress of the locally stored data reaches the specified standard, the target virtual machine can be controlled to be shut down, and the remaining locally stored data corresponding to the target virtual machine can be copied into the reserved resources. In addition, during the downtime, the target virtual machine can be switched to being bound to the reserved resources, and the target virtual machine can be migrated to the reserved resources. In this way, the target virtual machine and the locally stored data of the target virtual machine can be migrated to the reserved resources, and the time consumed by the migration of the locally stored data is independent of the migration execution period of the virtual machine. Therefore, the downtime of the virtual machine in the migration process can be effectively reduced.

**[0053]** FIG. 3 is a schematic flowchart of a virtual machine migration method according to another exemplary embodiment of the present disclosure. Referring to FIG. 3, the method may include the following steps.

**[0054]** Step 300: On a premise that a target virtual machine is kept bound to resources currently occupied by the target virtual machine at a migration source end, define, from a migration destination end, physical resources whose specification matches a specification of the currently occupied resources as reserved resources allocated to the target virtual machine.

**[0055]** Step 301: Configure a clone identifier for the target virtual machine.

**[0056]** Step 302: Establish a resource binding relationship between the clone identifier and the reserved resources, to allocate the reserved resources to the target virtual machine.

**[0057]** Step 303: Copy locally stored data corresponding to the target virtual machine at the

migration source end into the reserved resources during running of the target virtual machine based on the currently occupied resources.

**[0058]** Step 304: If a copying progress of the locally stored data reaches a specified standard, control the target virtual machine to be shut down, and copy remaining locally stored data corresponding to the target virtual machine into the reserved resources.

**[0059]** Step 305: Switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources.

**[0060]** For step 303 to step 305, reference can be made to related descriptions in the foregoing embodiments, and details are not described herein again.

**[0061]** In this embodiment, based on step 300 to step 302, an exemplary implementation of a resource reservation mechanism is provided. The following provides a detailed description of this exemplary implementation.

**[0062]** In the exemplary implementation, the management and control device can maintain a resource binding relationship for each virtual machine. The resource binding relationship records an identifier of the virtual machine and description information of resources to which the virtual machine is bound. In step 300, the management and control device can keep the resource binding relationship between the target virtual machine device and the resources currently occupied by the target virtual machine device at the migration source end unchanged, to keep the target virtual machine bound to the resources currently occupied by the target virtual machine device at the migration source end.

**[0063]** On this premise, in step 300, the management and control device may define, from the migration destination end, the physical resources whose specification matches the specification of the resources currently occupied by the target virtual machine at the migration source end as the reserved resources, and allocate the reserved resources to the target virtual machine. Specification matching means that the defined reserved resources have a sufficiently large specification to ensure that the target virtual machine can be carried. Preferably, the specification of the reserved resources may be completely consistent with the specification of the resources currently occupied by the target virtual machine at the migration source end. Certainly, the specification of the reserved resources may alternatively be greater than the specification of the currently occupied resources, to ensure that the reserved resources can completely carry the target virtual machine and the locally stored data of the target virtual machine. As mentioned above, the target virtual machine cannot be simultaneously bound to physical resources on a plurality of physical servers. Therefore, the occupation right of the target virtual machine to the reserved resources cannot be implemented in a resource binding manner.

**[0064]** In view of this, in step 301, it is proposed that the clone identifier is configured for the

target virtual machine. In addition, in step 302, the resource binding relationship may be established between the clone identifier and the reserved resources. A format of the resource binding relationship between the clone identifier and the reserved resources is consistent with a format of the resource binding relationship that the target virtual machine is in. In other words, in addition to the resource binding relationship between the target virtual machine and the resources to which the target virtual machine is bound at the migration source end, a new resource binding relationship is established. Binding parties in the new resource binding relationship are respectively the clone identifier associated with the target virtual machine and the reserved resources allocated to the target virtual machine. In this way, the original resource binding relationship that the target virtual machine is in is not affected by the resource binding relationship created for the clone identifier, and the two resource binding relationships are independent of each other. In an actual application, the resource binding relationship may usually be in a format of a data table or the like. This is not limited herein.

**[0065]** In this embodiment, the clone identifier is a custom identifier that is different from an original identifier of the target virtual machine, but has an association relationship with the target virtual machine. Based on this, in one aspect, the clone identifier is inconsistent with the original identifier of the target virtual machine. Therefore, the identifier of the target virtual machine will not be bound to the physical resources of a plurality of physical servers at the same time. From the cognitive perspective of the management and control device, the identifier of the target virtual machine is bound only to the resources currently occupied by the target virtual machine at the migration source end and is not bound to the reserved resources, thereby ensuring that the target virtual machine can normally run at the migration source end. In another aspect, from the cognitive perspective of the management and control device, the reserved resources are in a determined resource binding relationship, which ensures that the reserved resources are in an occupied state. Because there is the association relationship between the clone identifier and the target virtual machine, the clone identifier essentially occupies the reserved resources on behalf of the target virtual machine.

**[0066]** It can be known that in this exemplary implementation, by binding the reserved resources to the clone identifier in place of the target virtual machine, the reserved resources can be allocated to the target virtual machine. In other words, the clone identifier may be used as an intermediary, to indirectly implement the occupation right of the target virtual machine to the reserved resources.

**[0067]** Preferably, the clone identifier itself may be used as a resource occupying body, and the clone identifier is not used to refer to any virtual machine entity. In other words, although the clone identifier is defined, in this exemplary implementation, there is no need to create a clone

virtual machine for the target virtual machine, and only a clone identifier is configured for the target virtual machine. From the cognitive perspective of the management and control device, if there is a resource occupying body (that is, the clone identifier corresponding to the target virtual machine) in the resource binding relationship to which the reserved resources belong, the management and control device can recognize that the reserved resources are definitely occupied. Moreover, the management and control device also recognizes that there is the association relationship between the target virtual machine and the clone identifier. Therefore, the management and control device can recognize the occupation right of the target virtual machine to the reserved resources by using the clone identifier as the intermediary when the target virtual machine is not bound to the reserved resources.

**[0068]** Continuing the exemplary implementation, in step 305, the target virtual machine may alternatively be switched to being bound to the reserved resources by using the resource binding relationship between the clone identifier and the reserved resources.

**[0069]** In an exemplary switching solution, the resource binding relationship between the target virtual machine and the resources currently occupied by the target virtual machine at the migration source end may be released; the clone identifier corresponding to the target virtual machine is searched for; and in the resource binding relationship that the clone identifier is in, the clone identifier is replaced with the identifier of the target virtual machine, to switch the target virtual machine to being bound to the reserved resources. In this exemplary switching solution, the resource binding relationship between the clone identifier and the reserved resources is modified, and the clone identifier therein is replaced with the identifier of the target virtual machine, so that the resource binding relationship is changed to the resource binding relationship between the target virtual machine and the reserved resources. The resource binding relationship between the target virtual machine and the resources currently occupied by the target virtual machine at the migration source end will be released.

**[0070]** In another exemplary switching solution, the clone identifier corresponding to the target virtual machine may be searched for; description information of the reserved resources is obtained from the binding relationship that the clone identifier is in; and in the resource binding relationship corresponding to the target virtual machine, description information of the currently occupied resources is replaced with the description information of the reserved resources, to switch the target virtual machine to being bound to the reserved resources. In this exemplary switching solution, the original resource binding relationship that the target virtual machine is in is modified, and the description information of the original physical resources therein (that is, the resources currently occupied by the target virtual machine at the migration source end) is replaced with the description information of the reserved resources, so that the resource binding relationship is

changed to the resource binding relationship between the target virtual machine and the reserved resources. The resource binding relationship between the clone identifier and the reserved resources will be released.

**[0071]** Regardless of which of the foregoing switching solutions is used, finally, the clone identifier may be hidden, the resource binding relationship between the target virtual machine and the reserved resources is directly established, and the resource binding relationship between the target virtual machine and the resources currently occupied by the target virtual machine at the migration source end is unbound. Therefore, the target virtual machine can be switched to being bound to the reserved resources.

**[0072]** In conclusion, in the implementation of the foregoing resource reservation mechanism, the clone identifier may be configured for the target virtual machine, and the clone identifier is used as the resource occupying body for the reserved resources, so that the reserved resources can be indirectly allocated to the target virtual machine based on the association relationship between the target virtual machine and the clone identifier, to implement the occupation right of the target virtual machine to the reserved resources without affecting normal running of the target virtual machine at the migration source end.

**[0073]** It should be understood that the implementation of the resource reservation mechanism provided in FIG. 3 is merely exemplary, and in this embodiment, the resource reservation mechanism may alternatively be implemented by using other implementations. For example, a blank clone virtual machine having the same specification is created at the migration destination end for the target virtual machine, and the reserved resources are occupied by using the clone virtual machine. After the target virtual machine is shut down, an identifier of the clone virtual machine is modified to the identifier of the target virtual machine, to complete switching of the resource binding relationship. Details are not described herein.

**[0074]** In addition, it should be noted that, some procedures described in the foregoing embodiments and accompanying drawings include a plurality of operations appearing in a specific sequence. However, it should be clearly understood that the operations may not be executed according to the sequence presented herein or may be executed in parallel. Sequence numbers of the operations, such as 201 and 202, are merely used for distinguishing different operations, and the sequence numbers do not indicate any execution sequence.

**[0075]** Referring to FIG. 1, the present disclosure may further provide a virtual machine management and control system. The system may include a management and control device and a plurality of physical servers. The plurality of physical servers may include a migration source end at which a target virtual machine is located and a migration destination end determined for the target virtual machine. The target virtual machine may be any virtual machine that needs to be

migrated. In addition, in this embodiment, a process of determining the migration destination end for the target virtual machine is not limited. For example, a load balancing policy may be used to determine the migration destination end for the target virtual machine.

**[0076]** Based on this, the management and control device in this embodiment may be configured to: allocate reserved resources to the target virtual machine from the migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at the migration source end; send a data pre-copying task to the migration source end during running of the target virtual machine at the migration source end; control the target virtual machine to be shut down if a copying progress of the locally stored data reaches a specified standard; and after copying of the locally stored data is completed, switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources.

**[0077]** Correspondingly, the migration source end in this embodiment may be configured to: execute the data pre-copying task, to trigger copying the locally stored data corresponding to the target virtual machine into the reserved resources; and continue to copy remaining locally stored data corresponding to the target virtual machine into the reserved resources after the target virtual machine is shut down.

**[0078]** It should be understood that, a work division manner among the management and control device, the migration source end, and the migration destination end provided in this embodiment is exemplary, and the present disclosure is not limited thereto. In this embodiment, other work division manners may also be used to implement migration of the target virtual machine.

**[0079]** For example, the management and control device may alternatively issue the data pre-copying task to the migration destination end. In this way, the migration destination end may actively establish a data copying channel to the migration source end, and take the lead in completing the data pre-copying task. The present disclosure is not limited to the foregoing data pre-copying task completed by the migration source end.

**[0080]** Alternatively, the management and control device may autonomously complete the data pre-copying task, and the migration source end and the migration destination end serve as cooperating parties. In this case, the management and control device may first copy the locally stored data corresponding to the target virtual machine at the migration source end to the management and control device itself, and then copy the data into the reserved resources at the migration destination end.

**[0081]** No further examples of work division manners are described for other work links here. However, it should be understood that, in this embodiment, when it is ensured that targets such as data copying and virtual machine migration are completed, the work division manner among the

management and control device, the migration source end, and the migration destination end can be flexibly changed.

**[0082]** In addition, for specific technical details in a related work link in this embodiment, reference can be made to the descriptions in the foregoing method embodiments. For brevity, details are not described herein. However, this should not cause a loss to the protection scope of the virtual machine management and control system in the present disclosure.

**[0083]** FIG. 4 is a schematic structural diagram of a management and control apparatus according to another exemplary embodiment of the present disclosure. Referring to FIG. 4, the management and control apparatus may include a resource reservation service module 40, a locally stored data migration module 41, and a virtual machine migration module 42. Referring to FIG. 4, the management and control apparatus provided in this embodiment may be deployed at a management and control layer, and the management and control layer may be located between a virtual machine layer and a physical resource layer. The physical resource layer includes various physical resources on a plurality of physical servers, and the virtual machine layer includes a plurality of virtual machines. The management and control apparatus in this embodiment may manage and control physical resources in the physical resource layer and each virtual machine in the virtual machine layer through modules included in the management and control apparatus.

**[0084]** The following describes modules of the management and control apparatus in this embodiment in detail by using a migration process of a target virtual machine as an example.

**[0085]** In this embodiment, the resource reservation service module 40 may be configured to allocate reserved resources to the target virtual machine from a migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at a migration source end.

**[0086]** The locally stored data migration module 41 may be configured to: trigger copying locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources during running of the target virtual machine at the migration source end; and if a copying progress of the locally stored data reaches a specified standard, control the target virtual machine to be shut down and then trigger copying remaining locally stored data corresponding into the target virtual machine into the reserved resources.

**[0087]** The virtual machine migration module 42 may be configured to: during downtime of the target virtual machine, switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources.

**[0088]** In an optional implementation of allocating the reserved resources to the target virtual machine from the migration destination end, the resource reservation service module 40 may be configured to:

define, from the migration destination end, physical resources whose specification matches a specification of the currently occupied resource as the reserved resources;

configure a clone identifier for the target virtual machine; and

establish a resource binding relationship between the clone identifier and the reserved resources, to allocate the reserved resources to the target virtual machine.

**[0089]** In an optional implementation of switching the target virtual machine to being bound to the reserved resources, the virtual machine migration module 42 may be configured to:

release a resource binding relationship between the target virtual machine and the currently occupied resources;

search for a clone identifier corresponding to the target virtual machine; and

replace, in a resource binding relationship that the clone identifier is in, the clone identifier with an identifier of the target virtual machine, to switch the target virtual machine to being bound to the reserved resources.

**[0090]** In another optional implementation of switching the target virtual machine to being bound to the reserved resources, the virtual machine migration module 42 may be configured to:

search for the clone identifier corresponding to the target virtual machine;

obtain description information of the reserved resources from the binding relationship that the clone identifier is in;

replace, in a resource binding relationship corresponding to the target virtual machine, description information of the currently occupied resources with the description information of the reserved resources, to switch the target virtual machine to being bound to the reserved resources; and

release the resource binding relationship between the clone identifier and the reserved resources.

**[0091]** Preferably, the clone identifier is used as a resource occupying body, and the clone identifier is not used to refer to any virtual machine entity.

**[0092]** FIG. 5 is a schematic diagram of working logic of a management and control apparatus according to another exemplary embodiment of the present disclosure. Referring to FIG. 5, FIG. 5 shows a schematic diagram of interaction logic between the resource reservation service module 40, the locally stored data migration module 41, the virtual machine migration module 42, the migration source end, and the migration destination end.

**[0093]** Referring to FIG. 5, a virtual machine migration requester may submit a resource reservation request to the resource reservation service module 40, and the resource reservation service module 40 may create a resource reservation instance in response to the resource reservation request, to allocate the reserved resources for the target virtual machine from the

migration destination end. The resource reservation instance may be understood as metadata used for describing the foregoing resource binding relationship between the clone identifier and the reserved resources. After the resource reservation instance is created, the allocation of the reserved resources to the target virtual machine can be realized.

**[0094]** Then, the virtual machine migration requester may submit a pre-copying task request of the locally stored data to the locally stored data migration module 41. The locally stored data migration module 41 may control, during running of the target virtual machine, the migration source end to pre-copy the locally stored data corresponding to the target virtual machine to the reserved resources at the migration destination end.

**[0095]** In an exemplary pre-copying solution, the locally stored data migration module 41 may be configured to:

in an initial round of copying, copy all locally stored data into the reserved resources; and

in a non-initial round of copying, determine dirty page data generated by running of the target virtual machine during a previous round of copying, and update the dirty page data to the reserved resources.

**[0096]** Preferably, it is determined that the copying progress of the locally stored data reaches the specified standard, if a data volume of the dirty page data generated by the running of the target virtual machine in a latest round of copying is less than a specified threshold.

**[0097]** After the pre-copying task is completed, the locally stored data migration module 41 may control the target virtual machine to be shut down. The virtual machine migration requester may continue to submit a virtual machine migration task request to the virtual machine migration module 42. In one aspect, the virtual machine migration module 42 may instruct the locally stored data migration module 41 to trigger copying the remaining locally stored data. In another aspect, the virtual machine migration module 42 may switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources. Referring to FIG. 5, the virtual machine migration module 42 may be configured to migrate, during downtime of the target virtual machine, components of the target virtual machine other than the locally stored data to the reserved resources.

**[0098]** After the migration is completed, the virtual machine migration module 42 may further control the target virtual machine to start up, so that the target virtual machine continues to run based on the reserved resources.

**[0099]** In an exemplary startup solution, the virtual machine migration module 42 may send a migration completion notification to a client (for example, the virtual machine migration requester shown in FIG. 5) corresponding to the target virtual machine, and after receiving a startup request

initiated by the client for the target virtual machine, schedule the startup request to the migration destination end, where the startup request includes description information of the reserved resources, to control the migration destination end to start up the target virtual machine based on the reserved resources.

**[0100]** It should be noted that, for technical details of the foregoing embodiments of the management and control apparatus, reference can be made to the related descriptions in the foregoing method embodiments. For brevity, details are not described herein again, but this should not cause a loss to the protection scope of the present disclosure.

**[0101]** FIG. 6 is a schematic structural diagram of a management and control device according to still another exemplary embodiment of the present disclosure. Referring to FIG. 6, the management and control device may include: a memory 60 and a processor 61.

**[0102]** The processor 61 is coupled to the memory 60 and configured to execute a computer program in the memory 60 to:

allocate reserved resources to a target virtual machine from a migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at a migration source end;

trigger copying locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources during running of the target virtual machine at the migration source end;

if a copying progress of the locally stored data reaches a specified standard, control the target virtual machine to be shut down and then trigger copying remaining locally stored data corresponding to the target virtual machine into the reserved resources; and

switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources.

**[0103]** In an optional embodiment, when allocating the reserved resources to the target virtual machine from the migration destination end, the processor 61 may be configured to:

define, from the migration destination end, physical resources whose specification matches a specification of the currently occupied resource as the reserved resources;

configure a clone identifier for the target virtual machine; and

establish a resource binding relationship between the clone identifier and the reserved resources, to allocate the reserved resources to the target virtual machine.

**[0104]** In an optional embodiment, when switching the target virtual machine to being bound to the reserved resources, the processor 61 may be configured to:

release a resource binding relationship between the target virtual machine and the currently occupied resources;

search for the clone identifier corresponding to the target virtual machine; and

replace, in the resource binding relationship that the clone identifier is in, the clone identifier with an identifier of the target virtual machine, to switch the target virtual machine to being bound to the reserved resources.

**[0105]** In an optional embodiment, when switching the target virtual machine to being bound to the reserved resources, the processor 61 may be configured to:

search for the clone identifier corresponding to the target virtual machine;

obtain description information of the reserved resources from the binding relationship that the clone identifier is in;

replace, in a resource binding relationship corresponding to the target virtual machine, description information of the currently occupied resource with the description information of the reserved resources, to switch the target virtual machine to being bound to the reserved resources; and

release the resource binding relationship between the clone identifier and the reserved resources.

**[0106]** In an optional embodiment, the clone identifier is used as a resource occupying body, and the clone identifier is not used to refer to any virtual machine entity.

**[0107]** In an optional embodiment, when copying the locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources, the processor 61 may be configured to:

in an initial round of copying, copy all locally stored data into the reserved resources; and

in a non-initial round of copying, determine dirty page data generated during a previous round of copying, and update the dirty page data to the reserved resources.

**[0108]** In an optional embodiment, the processor 61 may be further configured to:

determine that the copying progress of the locally stored data reaches the specified standard, if a data volume of the dirty page data generated in a latest round of copying is less than a specified threshold.

**[0109]** In an optional embodiment, when migrating the target virtual machine to the reserved resources, the processor 61 may be configured to:

migrate, during downtime of the target virtual machine, components of the target virtual machine other than the locally stored data to the reserved resources.

**[0110]** In an optional embodiment, after migrating the target virtual machine to the reserved resources, the processor 61 may be further configured to:

control the target virtual machine to start up, to enable the target virtual machine to

continue to run based on the reserved resources.

**[0111]** In an optional embodiment, in a process of controlling the target virtual machine to start up, the processor 61 may be configured to:

send a migration completion notification to a client corresponding to the target virtual machine; and after receiving a startup request initiated by the client for the target virtual machine, schedule the startup request to the migration destination end, where the startup request includes the description information of the reserved resources, to control the migration destination end to start up the target virtual machine based on the reserved resources.

**[0112]** Further, as shown in FIG. 6, the management and control device further includes other components such as a communication component 62 and a power supply component 63. Only some components are schematically provided in FIG. 6, which does not mean that the management and control device includes only the components shown in FIG. 6.

**[0113]** It should be noted that, for technical details of the foregoing embodiments of the management and control device, reference can be made to the related descriptions in the foregoing method embodiments. For brevity, details are not described herein again, but this should not cause a loss to the protection scope of the present disclosure.

**[0114]** Correspondingly, an embodiment of the present disclosure further provides a computer-readable storage medium storing a computer program. When the computer program is executed, the steps that may be executed by the management and control device in the foregoing method embodiments can be implemented.

**[0115]** Correspondingly, an embodiment of the present disclosure further provides a computer program. When the computer program is executed by a processor, steps that may be executed by the management and control device in the foregoing method embodiments are implemented.

**[0116]** The memory in FIG. 6 is configured to store the computer program, and may be configured to store various other data to support operations on a computing platform. Examples of the data include instructions for any application or method operated on the computing platform, contact data, phonebook data, messages, pictures, videos, and the like. The memory may be implemented by any type of volatile or non-volatile storage device or a combination thereof, such as a static random access memory (SRAM), an electrically erasable programmable read-only memory (EEPROM), an erasable programmable read-only memory (EPROM), a programmable read-only memory (PROM), a read-only memory (ROM), a magnetic memory, a flash memory, a magnetic disk, or an optical disc.

**[0117]** The communication component in FIG. 6 is configured to facilitate communication in a wired or wireless manner between a device in which the communication component is located and other devices. The device in which the communication component is located may access a

wireless network according to a communication standard, such as Wi-Fi, 2G, 3G, 4G/LTE, 5G or other mobile communication networks, or a combination thereof. In an exemplary embodiment, the communication component receives a broadcast signal or broadcast related information from an external broadcast management system through a broadcast channel. In an exemplary embodiment, the communication component further includes a near field communication (NFC) module, to promote short range communication. For example, the NFC module may be implemented based on a radio frequency identification (RFID) technology, an infrared data association (IrDA) technology, an ultra-wideband (UWB) technology, a Bluetooth (BT) technology, and other technologies.

**[0118]** The power supply component in FIG. 6 provides power to various components of a device in which the power supply component is located. The power supply component may include a power supply management system, one or more power supplies, and other components associated with generating, managing, and allocating power for the device in which the power supply component is located.

**[0119]** A person skilled in the art should understand that the embodiments of the present disclosure may be provided as a method, a system, or a computer program product. Therefore, the present disclosure may use a form of hardware-only embodiments, software-only embodiments, or embodiments combining software and hardware. In addition, the present disclosure may use a form of a computer program product implemented on one or more computer-usable storage media (including but not limited to a disk memory, a CD-ROM, an optical memory, and the like) including computer-usable program code.

**[0120]** The present disclosure is described with reference to flowcharts and/or block diagrams of the method, device (system), and computer program product in the embodiments of the present disclosure. It should be understood that computer program instructions can implement each procedure and/or block in the flowcharts and/or block diagrams and a combination of procedures and/or blocks in the flowcharts and/or block diagrams. These computer program instructions may be provided to a processor of a general-purpose computer, a special-purpose computer, an embedded processor, or other programmable data processing devices to generate a machine, so that an apparatus configured to implement functions specified in one or more procedures in the flowcharts and/or one or more blocks in the block diagrams is generated by using instructions executed by the processor of the computer or other programmable data processing devices.

**[0121]** These computer program instructions may also be stored in a computer-readable memory that can guide a computer or other programmable data processing devices to work in a specific manner, so that the instructions stored in the computer-readable memory generate an artifact that includes an instruction apparatus. The instruction apparatus implements functions

specified in one or more procedures in the flowcharts and/or in one or more blocks in the block diagrams.

**[0122]** These computer program instructions may also be loaded onto a computer or other programmable data processing devices, so that a series of operations and steps are performed on the computer or other programmable devices, thereby generating computer-implemented processing. Therefore, the instructions executed on the computer or other programmable devices provide steps for implementing functions specified in one or more procedures in the flowcharts and/or in one or more blocks in the block diagrams.

**[0123]** It should be further noted that the terms “include”, “comprise”, or any variants thereof are intended to cover a non-exclusive inclusion. Therefore, a process, method, article, or device that includes a series of elements not only includes such elements, but also includes other elements not specified expressly, or includes inherent elements of the process, method, article, or device. Without further restrictions, an element limited by “include a/an/one...” does not exclude other same elements existing in the process, method, article, or device that includes that element.

**[0124]** It should be noted that, user information (including, but not limited to, user equipment information, user personal information, and the like) and data (including, but not limited to, data for analysis, stored data, displayed data, and the like) involved in the present disclosure are information and data that are authorized by a user or that are sufficiently authorized by all parties. Related data needs to be collected, used, and processed in accordance with related laws and regulations and standards of related countries and regions, and a corresponding operation entry is provided for a user to select whether to grant or deny authorization.

**[0125]** The foregoing descriptions are merely embodiments of the present disclosure, and are not intended to limit the present disclosure. For a person skilled in the art, various modifications and variations can be made to the present disclosure. Any modification, equivalent replacement, improvement and the like made within the spirit and principle of the present disclosure shall fall within the protection scope of the present disclosure.

## CLAIMS

1. A virtual machine migration method, comprising:

allocating reserved resources to a target virtual machine from a migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at a migration source end;

triggering copying locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources during running of the target virtual machine at the migration source end;

if a copying progress of the locally stored data reaches a specified standard, controlling the target virtual machine to be shut down and then triggering copying remaining locally stored data corresponding to the target virtual machine into the reserved resources; and

switching the target virtual machine to being bound to the reserved resources, and migrating the target virtual machine to the reserved resources.

2. The method according to claim 1, wherein the allocating reserved resources to a target virtual machine from a migration destination end comprises:

defining, from the migration destination end, physical resources whose specification matches a specification of the resources currently occupied as the reserved resources;

configuring a clone identifier for the target virtual machine; and

establishing a resource binding relationship between the clone identifier and the reserved resources, to allocate the reserved resources to the target virtual machine.

3. The method according to claim 2, wherein the switching the target virtual machine to being bound to the reserved resources comprises:

releasing a resource binding relationship between the target virtual machine and the resources currently occupied;

searching for the clone identifier corresponding to the target virtual machine; and

replacing, in the resource binding relationship that the clone identifier is in, the clone identifier with an identifier of the target virtual machine, to switch the target virtual machine to being bound to the reserved resources.

4. The method according to claim 2, wherein the switching the target virtual machine to being bound to the reserved resources comprises:

searching for the clone identifier corresponding to the target virtual machine;

obtaining description information of the reserved resources from the resource binding relationship that the clone identifier is in;

replacing, in a resource binding relationship corresponding to the target virtual machine, description information of the resources currently occupied with the description information of the reserved resources, to switch the target virtual machine to being bound to the reserved resources; and

releasing the resource binding relationship between the clone identifier and the reserved resources.

5. The method according to any one of claims 1 to 4, wherein the triggering copying locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources comprises:

in an initial round of copying, copying all locally stored data into the reserved resources; and

in a non-initial round of copying, obtaining dirty page data generated by running of the target virtual machine during a previous round of copying, and updating the dirty page data to the reserved resources.

6. The method according to claim 5, wherein the method further comprises:

determining that the copying progress of the locally stored data reaches the specified standard if a data volume of the dirty page data generated by the running of the target virtual machine in a latest round of copying is less than a specified threshold.

7. The method according to any one of claims 1 to 6, wherein the migrating the target virtual machine to the reserved resources comprises:

migrating, during downtime of the target virtual machine, components of the target virtual machine other than the locally stored data to the reserved resources.

8. The method according to any one of claims 1 to 7, wherein after migrating the target virtual machine to the reserved resources, the method further comprises:

controlling the target virtual machine to start up, to enable the target virtual machine to continue to run based on the reserved resources.

9. The method according to claim 8, wherein the controlling the target virtual machine to start up, to enable the target virtual machine to continue to run based on the reserved resources comprises:

sending a migration completion notification to a client corresponding to the target virtual machine; and

after receiving a startup request initiated by the client for the target virtual machine, scheduling the startup request to the migration destination end, wherein the startup request comprises description information of the reserved resources, to control the migration destination end to start up the target virtual machine based on the reserved resources.

10. A management and control apparatus, comprising:

a resource reservation service module, configured to allocate reserved resources to a target virtual machine from a migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at a migration source end;

a locally stored data migration module, configured to: trigger copying locally stored data corresponding to the target virtual machine at the migration source end into the reserved resources during running of the target virtual machine at the migration source end; and if a copying progress of the locally stored data reaches a specified standard, control the target virtual machine to be shut down and then trigger copying remaining locally stored data corresponding to the target virtual machine into the reserved resources; and

a virtual machine migration module, configured to: during downtime of the target virtual machine, switch the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources.

11. The management and control apparatus according to claim 10, wherein the resource reservation service module is specifically configured to:

define, from the migration destination end, physical resources whose specification matches a specification of the resources currently occupied as the reserved resources;

configure a clone identifier for the target virtual machine; and

establish a resource binding relationship between the clone identifier and the reserved resources, to allocate the reserved resources to the target virtual machine.

12. A management and control device, comprising a memory and a processor, wherein

the memory is configured to store one or more computer instructions; and

the processor is coupled to the memory and is configured to execute the one or more computer instructions, to execute the virtual machine migration method according to any one of claims 1 to 9.

13. A virtual machine management and control system, comprising a management and control device, a migration source end at which a target virtual machine is located, and a migration destination end selected for the target virtual machine, wherein

the management and control device is configured to: allocate reserved resources to the target virtual machine from the migration destination end on a premise that the target virtual machine is kept bound to resources currently occupied by the target virtual machine at the migration source end; send a data pre-copying task for locally stored data corresponding to the target virtual machine to the migration source end during running of the target virtual machine at the migration source end; control the target virtual machine to be shut down if a copying progress of the locally stored data reaches a specified standard; and after copying of the locally stored data is completed, switch

the target virtual machine to being bound to the reserved resources, and migrate the target virtual machine to the reserved resources; and

the migration source end is configured to: execute the data pre-copying task, to trigger copying the locally stored data corresponding to the target virtual machine into the reserved resources; and continue to copy remaining locally stored data corresponding to the target virtual machine into the reserved resources after the target virtual machine is shut down.

14. A computer-readable storage medium storing computer instructions, wherein when the computer instructions are executed by one or more processors, the one or more processors are caused to execute the virtual machine migration method according to any one of claims 1 to 9.

15. A computer program, wherein when the computer program is executed by a processor, steps of the method according to any one of claims 1 to 9 are implemented.