selected sharing entry is not greater than a predetermined threshold, write information about one visitor of the recorded visitors to a single-pointer entry associated with the selected sharing entry, and send an invalidation message to the other visitors of the recorded visitors.

[0020] With reference to any one of the second aspect or the foregoing possible implementation manners of the second aspect, in a sixth possible implementation manner, the single-pointer entry includes a tag, a sharing-entry association bit, and a single pointer, where the tag is used to correspond to the data block, the sharing-entry association bit is used to indicate whether the single-pointer entry is associated with the sharing entry, and the single pointer is used to record the information about the single visitor of the data block when the data block has the single visitor and to record the information about the association between the single-pointer entry and the sharing entry when the single-pointer entry is associated with the sharing entry; and

the sharing entry includes a sharer record structure and an association structure, where the sharer record structure is used to record the information about the multiple visitors of the data block, and the association structure is used to associate the single-pointer entry.

[0021] With reference to the sixth possible implementation manner of the second aspect, in a seventh possible implementation manner, the single-pointer entry further includes anall sharing bit, where

the all sharing bit is used to: when the single-pointer entry is unassociated with the sharing entry, indicate that the data block has the single visitor or indicate that the data block is shared by all the processor cores in the multi-core system.

[0022] According to a third aspect, a multi-core system is provided, including multiple processor cores, a shared data cache, and the directory cache device according to the second aspect or any possible implementation manner of the second aspect.

[0023] According to a fourth aspect, a directory storage unit is provided, configured to store a directory that is in a multi-core system, where the multi-core system includes a shared data cache and multiple processor cores, a data block in the shared data cache is copied to at least one processor core of the multiple processor cores, the directory is used to record information about a visitor of the data block in the shared data cache, and the visitor of the data block is the processor core in which a copy of the data block is stored; and the directory includes:

a single-pointer entry array and a sharing entry array, where

each single-pointer entry in the single-pointer entry array is used to record information

about a single visitor of a data block, or record information about an association between the single-pointer entry and a sharing entry in the sharing entry array; and

each sharing entry in the sharing entry array is used to record information about multiple visitors of a data block.

[0024] With reference to the fourth aspect, in a first possible implementation manner, the single-pointer entry includes a tag, a sharing-entry association bit, and a single pointer, where the tag is used to correspond to the data block, the sharing-entry association bit is used to indicate whether the single-pointer entry is associated with the sharing entry, and the single pointer is used to record the information about the single visitor of the data block when the data block has the single visitor and to record the information about the association between the single-pointer entry and the sharing entry when the single-pointer entry is associated with the sharing entry; and

the sharing entry includes a sharer record structure and an association structure, where the sharer record structure is used to record the information about the multiple visitors of the data block, and the association structure is used to associate the single-pointer entry.

[0025] With reference to the first possible implementation manner of the fourth aspect, in a second possible implementation manner, the single-pointer entry includes an all sharing bit, where

the all sharing bit is used to: when the single-pointer entry is unassociated with the sharing entry, indicate that the data block has the single visitor or indicate that the data block is shared by all processor cores in the multi-core system.

[0026] With reference to the first or the second possible implementation manner of the fourth aspect, in a third possible implementation manner, the sharer record structure is a vector.

[0027] Based on the foregoing technical solutions, in the embodiments of the present invention, a directory structure including a single-pointer entry array and a sharing entry array is used. When a data block only has a single visitor, only a single-pointer entry is used to record information about the visitor. When the data block has multiple visitors, information about the visitors is recorded in a manner of associating a single-pointer entry with a sharing entry. In the foregoing manner, an average size of a directory entry in a directory can be relatively greatly compressed and a performance loss is relatively small. Therefore, storage resources occupied by the directory can be reduced and system scalability can be improved.

DESCRIPTION OF EMBODIMENTS

[0042] 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.

[0043] Throughout this specification, a term "multi-core processor system" or "multi-core system" refers to a processing system including multiple processor cores (Core). The system may be presented as an on-chip multi-core processor or an on-board multi-core processing system. The on-chip multi-core processor is a processor (Processor) in which multiple processor cores (Core) are integrated on one chip (Chip). The on-board multi-core processing system refers to a processing system that is formed by separately packaging each core of multiple processor cores into a processor and integrating the processors on a circuit board.

[0044] A core (Core) is also referred to as a kernel and is a most important component of a CPU (Central Processing Unit). The core is made of monocrystalline silicon by using a particular production process. All of computation, command receiving/storage, and data processing in the CPU are executed by a processor core. The term "multiple processor cores" means that at least two processor cores are included. The "multiple processor cores" cover a scope of multi-core (Multi-Core) and many-core (Many Core) applications in the prior art.

[0045] Throughout this specification, a term "directory cache", also referred to as "directory cache device", refers to a storage device used to store a data visitor directory in a multi-core system. To increase a directory access rate, the storage device is usually implemented in a form of cache (Cache). The directory cache is implemented in at least two implementation manners. In one manner, the directory cache is implemented independently of a processor core, that is, a piece of storage space in a cache (Cache) on an on-chip multi-core processing chip is allocated, so as to be used as a cache for directory storage. In another manner, the directory cache is implemented in a distributed manner, that is, a directory is divided into several blocks, and the directory blocks are separately stored in a cache inside each processor core on an on-chip multi-core processing chip.

[0046] Throughout this specification, a term "shared data cache" refers to a storage device used to store a data block shared by multiple cores. To increase a data block access rate, the storage device is usually implemented in a form of cache (Cache). In a specific implementation process, the shared data cache generally refers to a level 2 (L2) cache or a level 3 (L3) cache in a multi-core

[0059] A directory is a structure in which a visitor list is recorded. Based on this, the directory may also be expressed as a directory structure.

[0060] The directory is stored in the directory cache 130, and specifically, may be stored in a directory storage unit in the directory cache 130.

[0061] The directory cache may be centralized or may be distributed. Correspondingly, the directory may be a centralized directory, that is, a cache area is set in a multi-core system (for example, a multi-core processor chip) to store the directory. The directory may also be a distributed directory, that is, the directory is divided into blocks, and each directory part obtained after block division is stored in each processor core. For example, assuming that the multi-core system includes 128 processor cores, a directory may be divided into 128 parts that are stored in the 128 processor cores respectively.

[0062] FIG. 2 is a schematic diagram of a directory 200 according to an embodiment of the present invention.

[0063] As shown in FIG. 2, the directory 200 includes a single-pointer entry array 210 and a sharing entry array 220.

[0064] The single-pointer entry array 210 includes multiple single-pointer entries, and the sharing entry array 220 includes multiple sharing entries.

[0065] A single-pointer entry in the single-pointer entry array 210 is used to record information about a single visitor of a data block, or record information about an association between the single-pointer entry and a sharing entry in the sharing entry array 220. That is, the single-pointer entry may record the information about the single visitor of the data block when the data block has the single visitor, or record the information about the association between the single-pointer entry and the sharing entry in the sharing entry array 220 when the data block has multiple visitors. The sharing entry is used to record information about the multiple visitors of the data block.

[0066] In a scale-out (scale-out) application, most data has only one visitor. The data may be private data or show a private feature within a time period. Based on this, most directory entries only need to record information about a processor core, for example, a number of the processor core, by using a single pointer, and the directory entry is referred to as a single-pointer entry in the present invention. In addition, to track data that has multiple visitors, some directory entries still use a hardware structure (for example, a vector, a limited pointer, or another form) that can be used to track multiple visitors, and the directory entry is referred to as a sharing entry in the present invention. All single-pointer entries constitute a single-pointer entry array, and all sharing entries constitute a sharing entry array. There may be a relatively large quantity of entries in the single-pointer entry array, and a relatively small quantity of entries in the sharing entry array.

[0141] If the sharing entry array has no unused sharing entry and has a sharing entry that records information about only one visitor, the sharing entry that records the information about the only one visitor is selected, and the recorded information about the visitor is written to a single-pointer entry associated with the selected sharing entry.

[0142] If the sharing entry array has neither an unused sharing entry nor a sharing entry that records information about only one visitor, a sharing entry is selected according to the principle of least recently used. If a quantity of visitors recorded in the selected sharing entry is greater than a predetermined threshold, a single-pointer entry associated with the selected sharing entry is set to indicate that the data block is shared by all the processor cores in the multi-core system. If a quantity of visitors recorded in the selected sharing entry is not greater than a predetermined threshold, information about one visitor of the recorded visitors is written to a single-pointer entry associated with the selected sharing entry, and an invalidation message is sent to the other visitors of the recorded visitors.

[0143] That is, when a sharing entry is to be allocated, an unused sharing entry is preferentially used. If there is no unused sharing entry, a used sharing entry needs to be taken back, and a sharing entry that records only one visitor is preferentially selected. If there is no sharing entry that records only one visitor, a sharing entry that is least recently used is selected. When the sharing entry that records the only one visitor is taken back, the single visitor needs to be written to an associated single-pointer entry, which avoids a visitor information loss. When a sharing entry that records multiple visitors is taken back, a visitor list may be compressed in different manners according to a quantity of visitors and may be stored in an associated single-pointer entry. Specifically, if the quantity of visitors is greater than the predetermined threshold, the associated single-pointer entry is set to indicate that the data block is shared by all the processor cores, which may be referred to as up-conversion. If the quantity of visitors is not greater than the predetermined threshold, one visitor of the visitors is written to the associated single-pointer entry, and the invalidation message is sent to the other visitors, that is, only one visitor is kept, which may be referred to as down-conversion.

[0144] For example, as shown in FIG. 9b, when up-conversion is performed, an all sharing bit in the associated single-pointer entry is set to 1, indicating that the data block is shared by all the processor cores. When down-conversion is performed, only one visitor (number 3 visitor shown in FIG. 9b) is kept, and the visitor is recorded in the associated single-pointer entry.

[0145] The sharing entry that is taken back may be allocated to another data block. That is, in this embodiment of the present invention, a sharing entry may be dynamically allocated according to a change in data sharing. In this way, a directory resource is utilized more flexibly, and utilization of the directory resource can be improved.

CLAIMS

What is claimed is:

1. A method for accessing a data visitor directory in a multi-core system, applied to the multi-core system, wherein the multi-core system comprises a shared data cache and multiple processor cores, a data block in the shared data cache is copied to at least one processor core of the multiple processor cores, the multi-core system further comprises the data visitor directory, the directory is used to record information about a visitor of the data block in the shared data cache, and the visitor of the data block is the processor core in which a copy of the data block is stored;

the directory comprises a single-pointer entry array and a sharing entry array, wherein each single-pointer entry in the single-pointer entry array is used to record information about a single visitor of a data block, or record information about an association between the single-pointer entry and a sharing entry in the sharing entry array, and each sharing entry in the sharing entry array is used to record information about multiple visitors of a data block; and

the method comprises:

receiving a first access request sent by a first processor core, wherein the first access request is used to access an entry, corresponding to a first data block, in the directory;

determining, according to the first access request, that the single-pointer entry array has a first single-pointer entry corresponding to the first data block; and

when determining, according to the first single-pointer entry, that the sharing entry array has a first sharing entry associated with the first single-pointer entry, determining multiple visitors of the first data block according to the first sharing entry.

2. The method according to claim 1, wherein the single-pointer entry in the single-pointer entry array is further used to indicate that the data block is shared by all processor cores in the multi-core system, and the method further comprises:

when determining, according to the first single-pointer entry, that the sharing entry array has no first sharing entry associated with the first single-pointer entry, determining, according to the first single-pointer entry, a single visitor of the first data block or that the first data block is shared by all the processor cores in the multi-core system.

3. The method according to claim 1or 2, wherein the method further comprises:

receiving a second access request sent by a second processor core, wherein the second access request is used to access the entry, corresponding to the first data block, in the directory;

determining, according to the second access request, that the single-pointer entry array has the first single-pointer entry corresponding to the first data block;

when determining, according to the first single-pointer entry, that the sharing entry array has no sharing entry associated with the first single-pointer entry, determining, according to the first single-pointer entry, that the single visitor of the first data block is the first processor core; and

allocating the first sharing entry in the sharing entry array, establishing an association relationship between the first single-pointer entry and the first sharing entry, and recording, in the first sharing entry, the information about the first processor core and information about the second processor core.

4. The method according to claim 3, wherein the allocating the first sharing entry in the sharing entry array comprises:

if the sharing entry array has an unused sharing entry, selecting a sharing entry from the unused sharing entry as the first sharing entry; or

if the sharing entry array has no unused sharing entry and has a sharing entry that records information about only one visitor, selecting the sharing entry that records the information about the only one visitor as the first sharing entry; or

selecting a sharing entry according to the principle of least recently used as the first sharing entry if the sharing entry array has neither an unused sharing entry nor a sharing entry that records information about only one visitor.

5. The method according to any one of claims 1 to 4, wherein

the single-pointer entry comprises a tag, a sharing-entry association bit, and a single pointer, wherein the tag is used to correspond to the data block, the sharing-entry association bit is used to indicate whether the single-pointer entry is associated with the sharing entry, and the single pointer is used to record the information about the single visitor of the data block when the data block has the single visitor and to record the information about the association between the single-pointer entry and the sharing entry when the single-pointer entry is associated with the sharing entry; and

the sharing entry comprises a sharer record structure and an association structure, wherein the sharer record structure is used to record the information about the multiple visitors of the data block, and the association structure is used to associate the single-pointer entry.

6. The method according to claim 5, wherein the single-pointer entry further comprises an all sharing bit; and

the all sharing bit is used to: when the single-pointer entry is unassociated with the sharing entry, indicate that the data block has the single visitor or indicate that the data block is shared by all the processor cores in the multi-core system.

7. A directory cache device, comprising:

a directory storage unit, configured to store a data visitor directory that is in a multi-core

system, wherein the multi-core system comprises a shared data cache and multiple processor cores, a data block in the shared data cache is copied to at least one processor core of the multiple processor cores, the directory is used to record information about a visitor of the data block in the shared data cache, and the visitor of the data block is the processor core in which a copy of the data block is stored; and the directory comprises a single-pointer entry array and a sharing entry array, wherein each single-pointer entry in the single-pointer entry array is used to record information about a single visitor of a data block, or record information about an association between the single-pointer entry and a sharing entry in the sharing entry array, and each sharing entry in the sharing entry array is used to record information about multiple visitors of a data block; and

an execution unit, configured to:

receive a first access request sent by a first processor core, wherein the first access request is used to access an entry, corresponding to a first data block, in the directory;

determine, according to the first access request, that the single-pointer entry array has a first single-pointer entry corresponding to the first data block; and

when determining, according to the first single-pointer entry, that the sharing entry array has a first sharing entry associated with the first single-pointer entry, determine multiple visitors of the first data block according to the first sharing entry.

8. The directory cache device according to claim 7, wherein the single-pointer entry in the single-pointer entry array is further used to indicate that the data block is shared by all processor cores in the multi-core system, and the execution unit is further configured to:

when determining, according to the first single-pointer entry, that the sharing entry array has no first sharing entry associated with the first single-pointer entry, determine, according to the first single-pointer entry, a single visitor of the first data block or that the first data block is shared by all the processor cores in the multi-core system.

9. The directory cache device according to claim 7 or 8, wherein the execution unit is further configured to:

receive a second access request sent by a second processor core, wherein the second access request is used to access the entry, corresponding to the first data block, in the directory;

determine, according to the second access request, that the single-pointer entry array has the first single-pointer entry corresponding to the first data block;

when determining, according to the first single-pointer entry, that the sharing entry array has no sharing entry associated with the first single-pointer entry, determine, according to the first single-pointer entry, that the single visitor of the first data block is the first processor core; and

allocate the first sharing entry in the sharing entry array, establish an association relationship

between the first single-pointer entry and the first sharing entry, and record, in the first sharing entry, the information about the first processor core and information about the second processor core.

10. The directory cache device according to claim 9, wherein the execution unit is configured to:

if the sharing entry array has an unused sharing entry, select a sharing entry from the unused sharing entry as the first sharing entry; or

if the sharing entry array has no unused sharing entry and has a sharing entry that records information about only one visitor, select the sharing entry that records the information about the only one visitor as the first sharing entry; or

select a sharing entry according to the principle of least recently used as the first sharing entry if the sharing entry array has neither an unused sharing entry nor a sharing entry that records information about only one visitor.

11. The directory cache device according to any one of claims 7 to 10, wherein

the single-pointer entry comprises a tag, a sharing-entry association bit, and a single pointer, wherein the tag is used to correspond to the data block, the sharing-entry association bit is used to indicate whether the single-pointer entry is associated with the sharing entry, and the single pointer is used to record the information about the single visitor of the data block when the data block has the single visitor and to record the information about the association between the single-pointer entry and the sharing entry when the single-pointer entry is associated with the sharing entry; and

the sharing entry comprises a sharer record structure and an association structure, wherein the sharer record structure is used to record the information about the multiple visitors of the data block, and the association structure is used to associate the single-pointer entry.

12. The directory cache device according to claim 11, wherein the single-pointer entry further comprises an all sharing bit; and

the all sharing bit is used to: when the single-pointer entry is unassociated with the sharing entry, indicate that the data block has the single visitor or indicate that the data block is shared by all the processor cores in the multi-core system.

13. A multi-core system, comprising multiple processor cores, a shared data cache, and the directory cache device according to any one of claims 7 to 12.

14. A directory storage unit, configured to store a data visitor directory that is in a multi-core system, wherein the multi-core system comprises a shared data cache and multiple processor cores, a data block in the shared data cache is copied to at least one processor core of the multiple processor cores, the directory is used to record information about a visitor of the data block in the shared data cache, and the visitor of the data block is the processor core in which a copy of the data

block is stored; and the directory comprises:

a single-pointer entry array and a sharing entry array, wherein

each single-pointer entry in the single-pointer entry array is used to record information about a single visitor of a data block, or record information about an association between the single-pointer entry and a sharing entry in the sharing entry array; and

each sharing entry in the sharing entry array is used to record information about multiple visitors of a data block.

15. The directory storage unit according to claim 14, wherein

the single-pointer entry comprises a tag, a sharing-entry association bit, and a single pointer, wherein the tag is used to correspond to the data block, the sharing-entry association bit is used to indicate whether the single-pointer entry is associated with the sharing entry, and the single pointer is used to record the information about the single visitor of the data block when the data block has the single visitor and to record the information about the association between the single-pointer entry and the sharing entry when the single-pointer entry is associated with the sharing entry; and

the sharing entry comprises a sharer record structure and an association structure, wherein the sharer record structure is used to record the information about the multiple visitors of the data block, and the association structure is used to associate the single-pointer entry.

16. The directory storage unit according to claim 15, wherein the single-pointer entry comprises an all sharing bit; and

the all sharing bit is used to: when the single-pointer entry is unassociated with the sharing entry, indicate that the data block has the single visitor or indicate that the data block is shared by all processor cores in the multi-core system.

17. The directory storage unit according to claim 15 or 16, wherein the sharer record structure is a vector.