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[Continued on next page]

(54) **Title:** MULTI-WAY CHECKPOINTS IN A DATA STORAGE SYSTEM

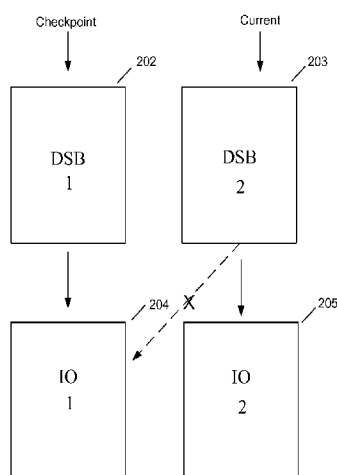


Fig. 19

(57) **Abstract:** Certain embodiments of the present invention allow multiple checkpoints to be taken so that multiple versions of the file system, including a working version and at least two checkpoint versions, can be maintained over time. Specifically, at least three 'superblock' root structures are used to manage multiple instantiations of the file system. The superblock locks are preferably stored in fixed locations within the storage system for easy access, although they may alternatively be stored in other ways. The number of superblocks may be fixed or variable. Other embodiments provide for validation of objects and data structures in a data storage system.



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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/079308

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F17/30 G06F11/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/182301 A1 (PATTERSON HUGO [US] ET AL) 25 September 2003 (2003-09-25) abstract; figures 3-6,9,10 paragraph [0012] - paragraph [0014] paragraph [0044] - paragraph [0060]	1-22
X	WO 03/105026 A (NETWORK APPLIANCE INC [US]) 18 December 2003 (2003-12-18) abstract; figures 1-5 page 2, line 1 - page 3, line 23 page 6, line 21 - page 10, line 15	1-22
X	US 5 819 292 A (HITZ DAVID [US] ET AL) 6 October 1998 (1998-10-06) column 18, line 49 - column 24, line 9; figures 17-23B abstract	1-22

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search 30 June 2009	Date of mailing of the international search report 17/09/2009
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040. Fax: (+31-70) 340-3016	Authorized officer Wienold, Norbert
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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/097141 A1 (LOAFMAN ZACHARY M [US] ET AL) 5 May 2005 (2005-05-05) abstract paragraph [0027] - paragraph [0035] paragraph [0049] -----	1-22

INTERNATIONAL SEARCH REPORT

international application No.
PCT/US2008/079308

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.
2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-22

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-22

A method and apparatus for maintaining a plurality of checkpoint versions of a filesystem in a data storage system, the method comprising:
maintaining at least three superblocs in the data storage system, each superbloc representing a version of the filesystem including a working version of the filesystem represented by a designated current superbloc and at least two checkpoint versions of the filesystem represented by the other superblocs;
maintaining a plurality of indirection objects in the data storage system, wherein each superbloc includes a reference to one of the indirection objects such that each indirection object is referenced by at least one of the superblocs; and
at a designated checkpoint, retaining a copy of the working version of the filesystem including the indirection object referenced by said designated current superbloc as a new checkpoint version using a first designated superbloc and continuing to maintain the working version of the filesystem using a second designated superbloc, wherein the new checkpoint version supplants an earlier checkpoint version.

2. claims: 23-46

23. A method of validating a data structure in a storage system, the data structure comprising a table having a sequence of table entries, each table entry including a type field and a pointer field, the type field indicating whether the table entry is used or free, the pointer field including a reference to a next free table entry if the table entry is free such that the data structure includes at least one list of free table entries linked using pointer fields, the method comprising:
(a) maintaining a tracking structure in a memory, the tracking structure including a corresponding status field for each table entry, the status fields having an unmarked state and a marked state;
(b) processing the table entries sequentially and tracking the used and free table entries using the tracking structure, such tracking including marking the status fields corresponding to used table entries and marking the status fields corresponding to the next free table entries referenced in the pointer fields of free table entries; and
(c) determining validity of the data structure based on the tracking structure.

3. claims: 47-70

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

47. A method of providing for validation of an object stored in a storage system, the object having a plurality of object chunks, each object chunk associated with a chunk validator, the method comprising:
computing an object validator for the object using a reversible operation to combine the chunk validators, whereby the object validator can be updated based on at least one of an old chunk validator and a new chunk validator for a single chunk; and
storing the object validator for the object.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/US2008/079308
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