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(54) METHOD AND SYSTEM FOR BUILDING A DATABASE FROM BACKUP DATA IMAGES

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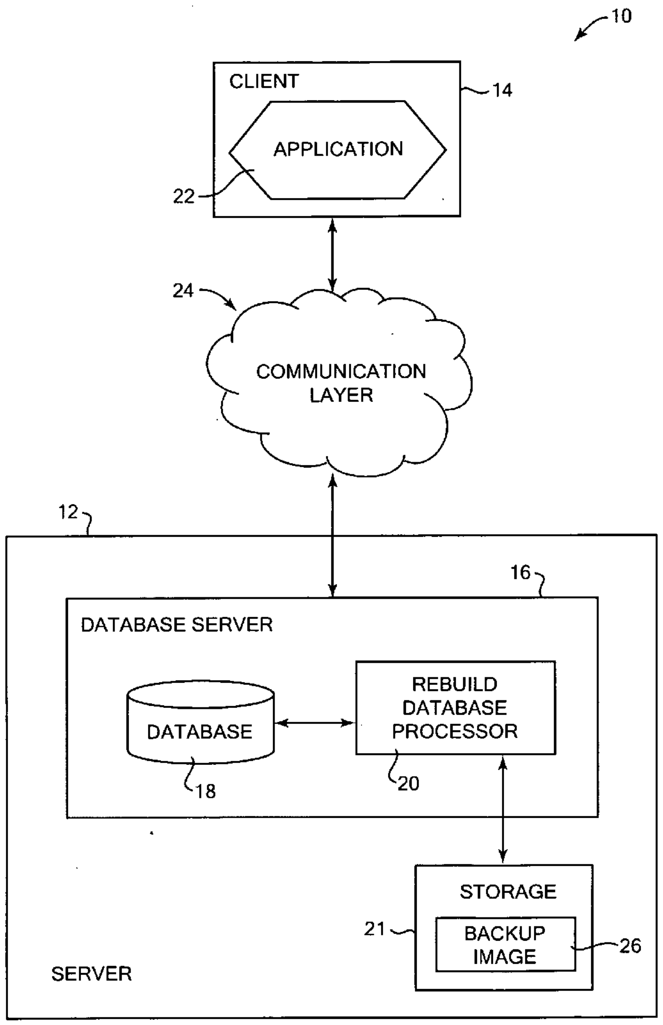
(57) **ABSTRACT**

Building a database from stored backup data images. In one aspect, an identification of a target image is received, the target image including a copy of a logical storage unit of data from a previous database and description information that describes the previous database. The target image holds a copy of a subset of the data of the previous database. A received list has at least one desired logical storage unit of data from the previous database to be included in a built database. The desired logical storage unit is restored from at least one stored data image to the built database using the description information in the target image. Other aspects include the target image being a database image, and the desired logical storage units of data being a subset of database data.



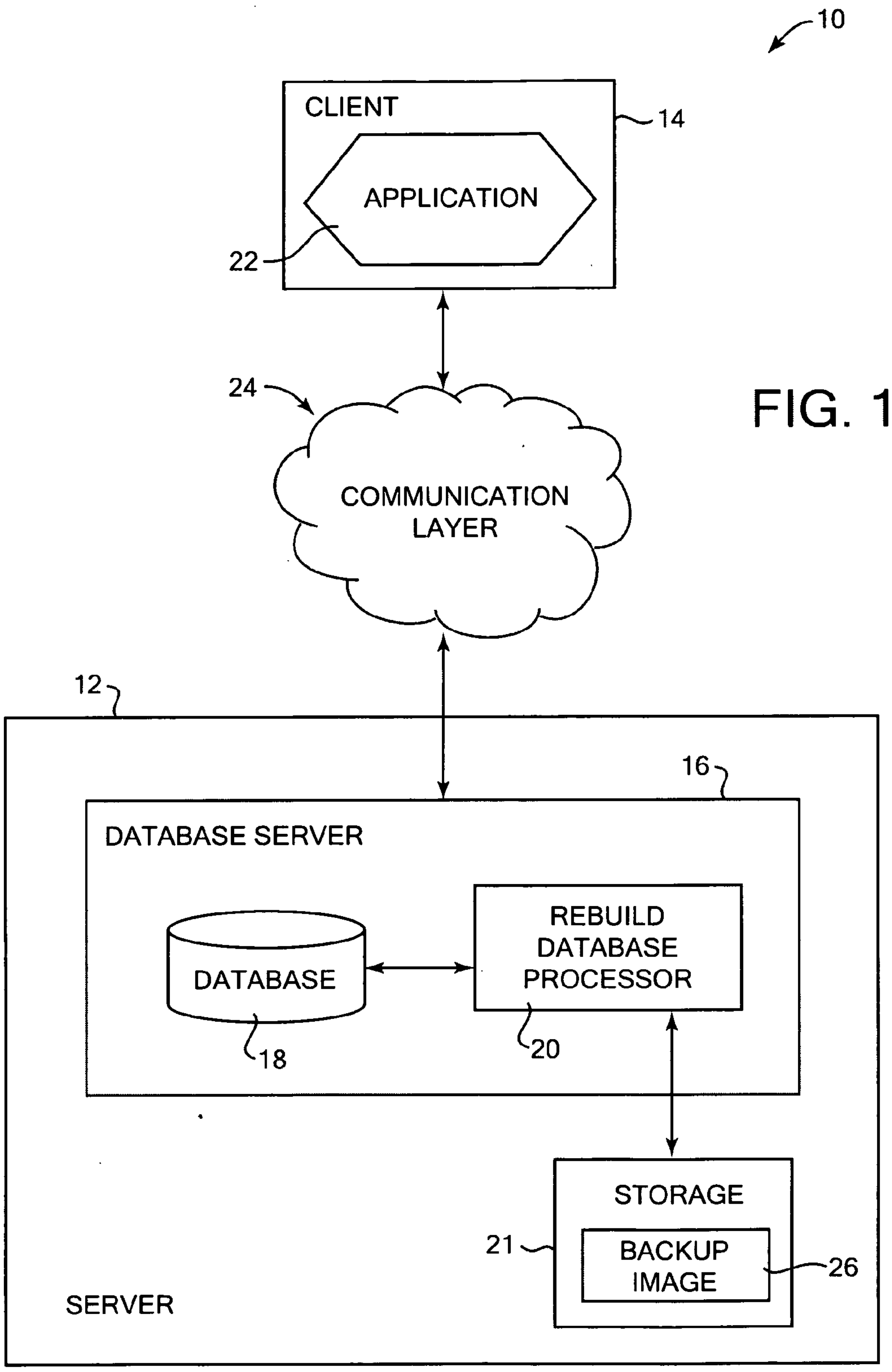

10
CLIENT
14
APPLICATION
22
24
COMMUNICATION LAYER
12
16
DATABASE SERVER
DATABASE
18
REBUILD DATABASE PROCESSOR
20
STORAGE
21
BACKUP IMAGE
26
SERVER

FIG. 1

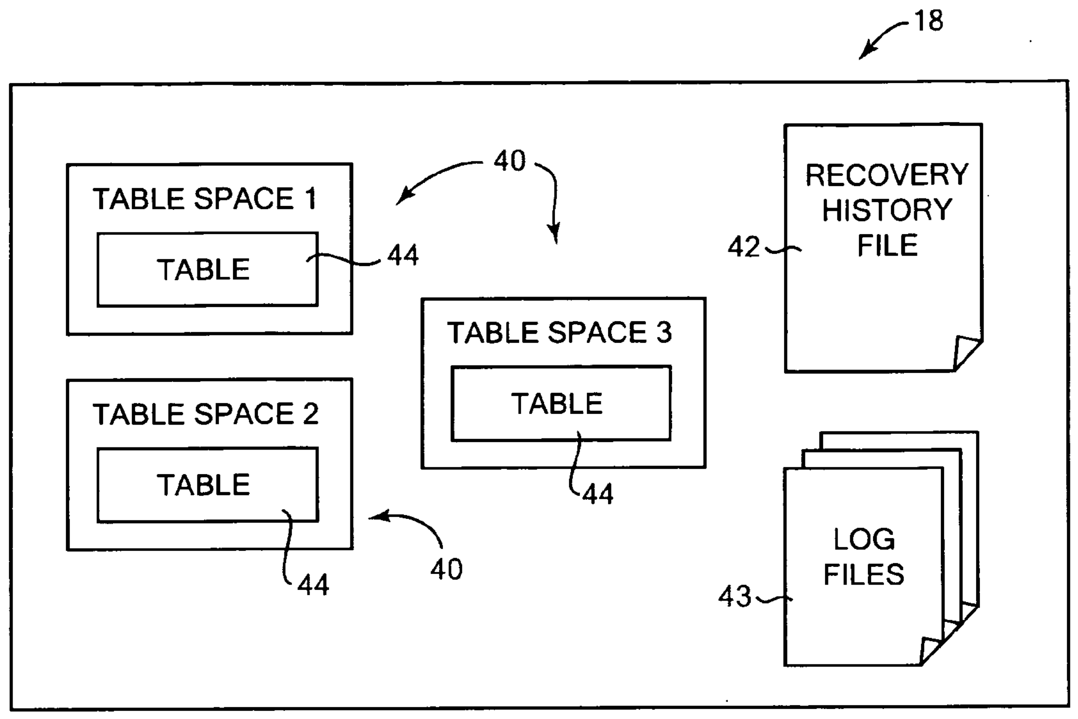

18
40
TABLE SPACE 1
TABLE
44
TABLE SPACE 2
TABLE
44
40
TABLE SPACE 3
TABLE
44
42
RECOVERY HISTORY FILE
43
LOG FILES

FIG. 2

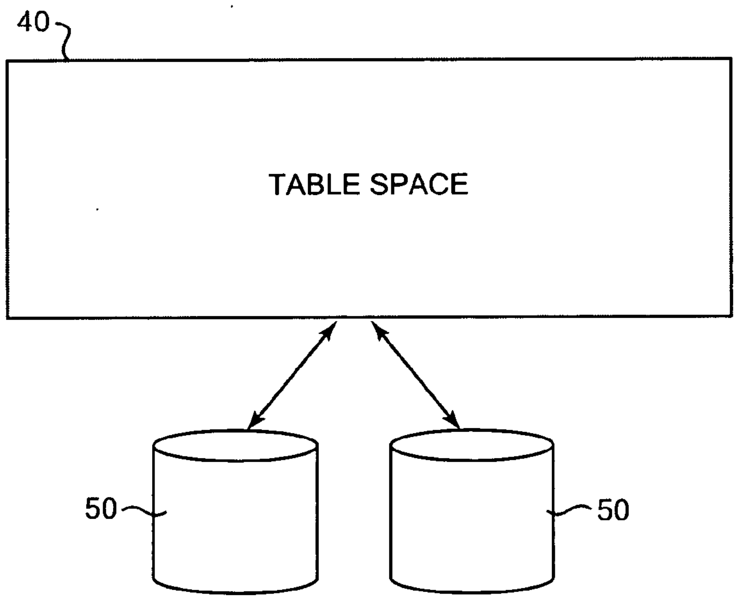

40
TABLE SPACE
50
50

FIG. 3

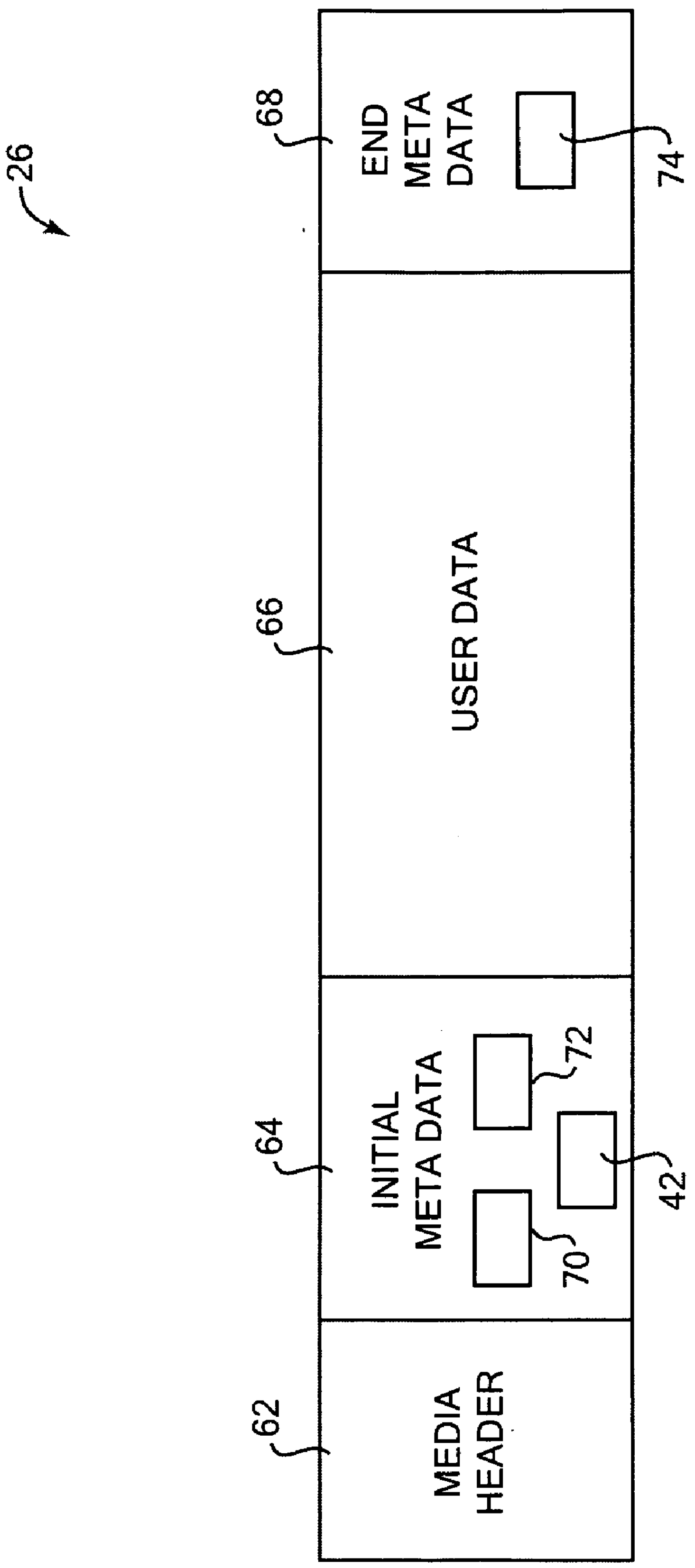

26
MEDIA HEADER
62
INITIAL META DATA
64
70
42
72
USER DATA
66
END META DATA
68
74

FIG. 4

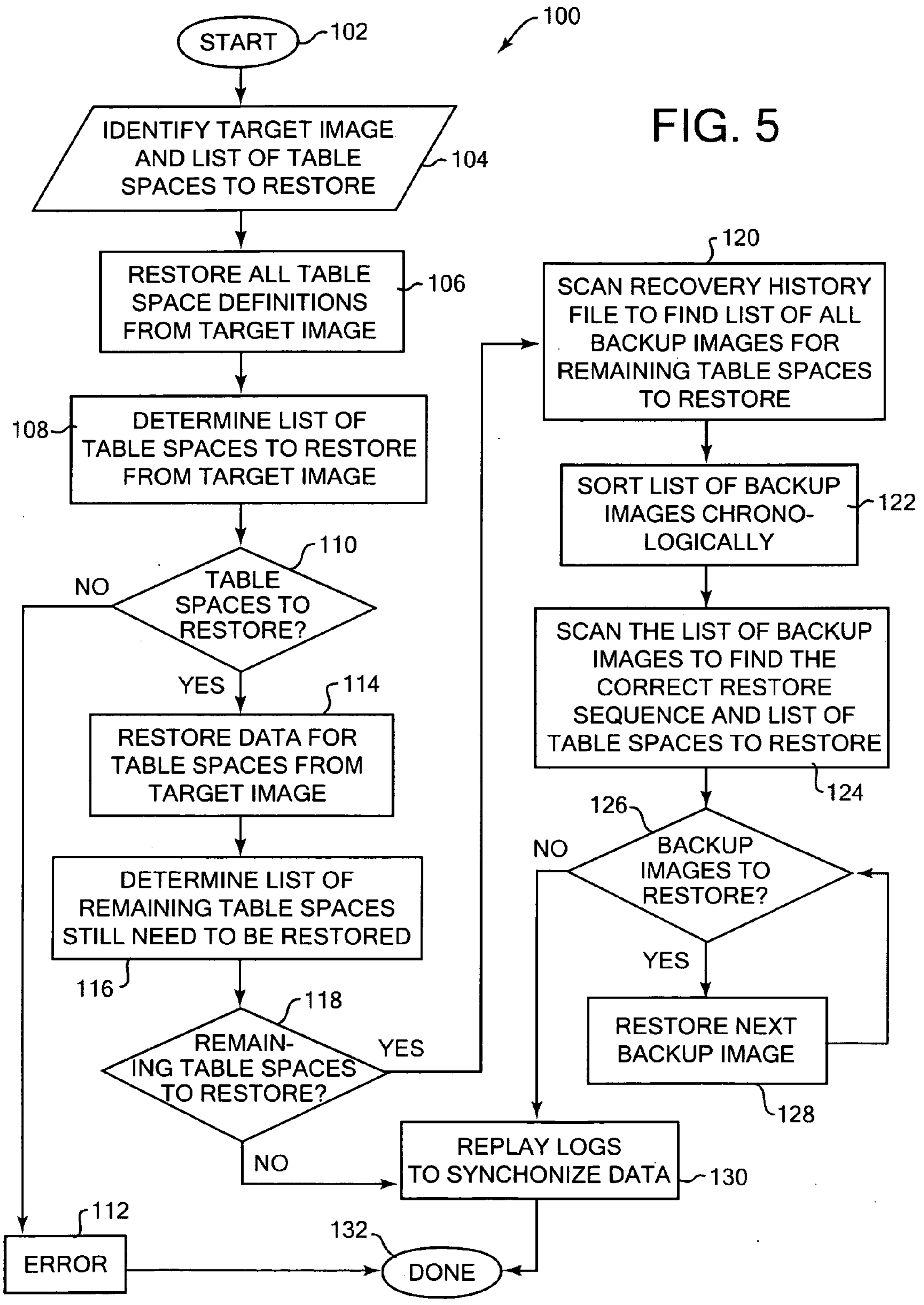

100
START
102
IDENTIFY TARGET IMAGE AND LIST OF TABLE SPACES TO RESTORE
104
RESTORE ALL TABLE SPACE DEFINITIONS FROM TARGET IMAGE
106
DETERMINE LIST OF TABLE SPACES TO RESTORE FROM TARGET IMAGE
108
TABLE SPACES TO RESTORE?
110
NO
YES
RESTORE DATA FOR TABLE SPACES FROM TARGET IMAGE
114
DETERMINE LIST OF REMAINING TABLE SPACES STILL NEED TO BE RESTORED
116
REMAIN-ING TABLE SPACES TO RESTORE?
118
YES
NO
SCAN RECOVERY HISTORY FILE TO FIND LIST OF ALL BACKUP IMAGES FOR REMAINING TABLE SPACES TO RESTORE
120
SORT LIST OF BACKUP IMAGES CHRONO-LOGICALLY
122
SCAN THE LIST OF BACKUP IMAGES TO FIND THE CORRECT RESTORE SEQUENCE AND LIST OF TABLE SPACES TO RESTORE
124
BACKUP IMAGES TO RESTORE?
126
NO
YES
RESTORE NEXT BACKUP IMAGE
128
REPLAY LOGS TO SYNCHONIZE DATA
130
ERROR
112
DONE
132

FIG. 5

METHOD AND SYSTEM FOR BUILDING A DATABASE FROM BACKUP DATA IMAGES

FIELD OF THE INVENTION

[0001] The present invention relates to computer database systems, and more particularly to building a database from stored backup data images.

BACKGROUND OF THE INVENTION

[0002] Database management systems store extensive amounts of organized information for access by users of the systems. In a database system environment, the system responds to specific inquiries from the user as to which data to present from the database. Users can specify classes or types of data to retrieve from the database according to the conditions and criteria of their queries. Typically, users provide queries in a particular syntax of a particular database language that is used by the system, such as Structured Query Language (SQL) format.

[0003] The data in a relational database is typically organized in multiple tables or data files, and a logical group of these tables or files are stored in a logical storage unit or logical group of data, referred to herein as a "table space." Each table space stores a subset of the database data and, all together, make up an entire database. In some databases, each table space might be organized to store tables of data that share a common characteristic, classification, or type, while in other databases, table spaces can each store different and varied types of data or data for a variety of uses. For example, one use of table spaces is to have each table space store only the data for one particular user of the database management system.

[0004] Database backups are typically performed periodically and routinely to create one or more copies of the database that store its data in safe, secondary storage areas, thus protecting the data of the database from unexpected data loss and errors. If data loss occurs in the active database, the data from a backup can be restored to reconstruct and recover the lost data. A set of backed up data is often referred to as a data "image."

[0005] A backup image can include the data from an entire database, or just include the data from one or more individual table spaces of the database. Backups are typically performed at specific times throughout the history of a database, and are typically performed at either database granularity (backup up the entire database) or table space granularity (backing up individual table spaces within the database). Furthermore, some backups are full backups that store all the data in the specified database or table space, while other backups are "incremental" backups that store only some of the data, e.g., only changes made since a previous backup.

[0006] One problem in the prior database management systems is that a user cannot build (restore or create) an entire database from a set of table space backup images, i.e., without ever having backed up a full database backup image. There are no existing tools or infrastructure to restore and synchronize multiple individual table space images into an entire database. One reason for this inability to restore the full database is that two different table space backup images are typically backed up at different times, and there is no existing way to restore the individual table spaces to a consistent point in time. For efficiency, many data backups are performed at a table space level, so that this can be a serious limitation; it requires that the system administrator perform full database backups if they wish to restore the entire database at a future date.

[0007] Furthermore, it is not possible with existing systems to build a database-level database by restoring only a subset of the database, made up of table spaces. The administrator is required to restore or create the entire database, including all the table spaces, even if the administrator wishes only to restore a subset of the database, such as individual table spaces.

[0008] Accordingly, what is needed is the ability to build an entire database from a subset of the database, such as table spaces, as well as the ability to build only a subset of data from a database. The present invention addresses such a need.

SUMMARY OF THE INVENTION

[0009] The invention of the present application relates to building a database from stored backup data images. In one aspect of the invention, a method for building a database from stored data images includes receiving an identification of a target image, where the target image includes a copy of at least one logical storage unit of data from a previous database, and description information that describes the previous database. The target image holds a copy of a subset of the data of the previous database. The method includes receiving a list of at least one desired logical storage unit of data to be included in a built database, where at least one desired logical storage unit is from the previous database. At least one desired logical storage unit is restored from at least one stored data image to the built database using the description information in the target image. Similar aspects of the invention are provided for a computer program product comprising a computer readable medium including program instructions for implementing similar features.

[0010] In another aspect, a method for building a database from stored data images includes receiving an identification of a target image, where the target image includes a copy of at least one logical storage unit of data from a previous database, and description information that describes the previous database. The target image holds a copy of a subset of the data of the previous database. The method includes receiving a list of at least one desired logical storage unit of data to be included in a database-level built database, where at least one desired logical storage unit is from the previous database and is a subset of data from the previous database. At least one desired logical storage unit is restored from the target image to the built database using the description information in the target image.

[0011] In another aspect, a system for building a database from stored data images includes a database for storing a built database, and a data storage that stores a target image, where the target data image includes a copy of a table space of data from a previous database, and description information that describes the previous database. The target image holds a copy of a subset of the data of the previous database. The system also includes a build processor in communication with the database and the data storage, which can receive an identification of the target image and a list of at least one desired table space of data to be included in the built database. At least one desired table space is from the previous database, where the build processor restores the at least one desired table space from a stored data image to the built database using the description information in the target image.

[0012] The present invention provides a method and system allowing a user to build or restore an entire database from different backup images, even images from different points in time. An administrator thus need not always perform lengthy full database backups in order to have the ability to restore the entire database in the future. In addition, the present invention allows a subset of an entire database to be restored or created at a database level using any type of backup image, including backup images from different points in time. Thus, administrators can decide on the order in which data subsets, such as table spaces, are restored and recovered, so that critical table spaces can be recovered in a timely manner, and the recovery of less important table spaces can be delayed until time permits.

BRIEF DESCRIPTION OF THE FIGURES

[0013] FIG. **1** is a block diagram illustrating a system of the present invention;

[0014] FIG. **2** is a block diagram illustrating a database **18** suitable for use with the present invention;

[0015] FIG. **3** is a block diagram illustrating one example of data storage implementation for the database of FIG. **1**;

[0016] FIG. **4** is a diagrammatic illustration of an example of a backup data image suitable for use with the present invention; and

[0017] FIG. **5** is a flow diagram illustrating a method of the present invention for building a complete or partial database from backup data images.

DETAILED DESCRIPTION

[0018] The present invention relates to computer database systems, and more particularly to building a database from stored backup data images. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiment and the generic principles and features described herein will be readily apparent to those skilled in the art. Thus, the present invention is not intended to be limited to the embodiment shown but is to be accorded the widest scope consistent with the principles and features described herein.

[0019] The present invention is mainly described in terms of particular systems provided in particular implementations. However, one of ordinary skill in the art will readily recognize that this method and system will operate effectively in other implementations. For example, the system implementations usable with the present invention can take a number of different forms. The present invention will also be described in the context of particular methods having certain steps. However, the method and system operate effectively for other methods having different and/or additional steps not inconsistent with the present invention.

[0020] The invention can take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment containing both hardware and software elements. In a preferred embodiment, the invention is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc.

[0021] Furthermore, the invention can take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0022] Furthermore, the invention can take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

[0023] The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk—read only memory (CD-ROM), compact disk—read/write (CD-R/W) and DVD.

[0024] A data processing system suitable for storing and/or executing program code will include at least one processor coupled directly or indirectly to memory elements through a system bus. The memory elements can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution.

[0025] Input/output or I/O devices (including but not limited to keyboards, displays, pointing devices, etc.) can be coupled to the system either directly or through intervening I/O controllers.

[0026] Network adapters may also be coupled to the system to enable the data processing system to become coupled to other data processing systems or remote printers or storage devices through intervening private or public networks. Modems, cable modem and Ethernet cards are just a few of the currently available types of network adapters.

[0027] To more particularly describe the features of the present invention, please refer to FIGS. **1-5** in conjunction with the discussion below.

[0028] FIG. **1** is a block diagram illustrating a system **10** of the present invention. System **10** includes exemplary components, such as a server **12** and a client **14**.

[0029] Server **12** is implemented as a computer system or electronic device. For example, the server **12** can be a mainframe computer, desktop computer, workstation, portable computer, or electronic device. One or more microprocessors and memory devices (not shown) control the operation of the server, including data manipulation, computation, input/output, and other typical functions.

[0030] The server **12** includes one or more database servers **16**, which are implemented on the server **12** and performs functions and operations specific to a database system. A database server **16** can include the necessary software to, for example, send and receive appropriate database commands and data, read and write data to a database, allocate space for and organize data, etc. For example, the database server **16** can be implemented based on a known standard, such as DB2 from IBM Corporation, or other database standards.

[0031] One or more databases **18** are included in database server **16**, where a database **18** is an entity that includes user data as well as information and functions needed to implement the data storage. The database server **16** organizes data in database **18** according to rules and structures as specified by the database creator and administrator. One example of data organization in database **18** is described below with respect to FIG. **2**. The storage of data in the database **18** is implemented using one or more storage devices, such as hard disks, magnetic tape, optical storage devices (CD, DVD, etc.), or other types of storage media, one example of which is described below with reference to FIG. **3**. In an alternate embodiment, the database **18** can be distributed among multiple computer systems or electronic devices, such as multiple servers **12**.

[0032] Database server **16** also includes an automatic rebuild database processor **20** ("build processor") of the present invention. Build processor **20** can be implemented as a software unit in the database server **16**, and/or as processor hardware and circuitry. The build processor **20** can automatically build a complete or partial database from stored data images according to the method of the present invention, as described in further detail below with respect to FIG. **5**.

[0033] Data storage **21** can also be implemented in server **12** (in alternate embodiments, the storage **21** can be implemented externally to the server **12**). Storage **21** can be, for example, any electronic data storage that can communicate with the database server **16**. In the embodiment of FIG. **1**, the storage **21** stores one or more backup images **26**, which are copies of the entire database **18**, or copies of subsets or portions of the database **18**, which are stored separately from the database **18** for archival or backup purposes, and which can be restored to the database **18**. Changes to the database occurring after the backup date of the restored backup image **26** can also be restored by applying archived and/or online logs, which are records of changes applied to the database at any given time. Backup image **26** may also contain incremental data, which is data resulting from an incremental backup and includes only data that changed relative to a previous backup image. Herein, the term "stored" is often used to refer to the backing up of a backup image **26** in a storage area such as storage **21**.

[0034] For example, if some data in the database **18** is lost due to a device malfunction or other error, a previous copy of the data stored in storage **21** in the form of a backup image **26** can be restored by retrieving it from storage **21** and writing it over the corresponding data and storage in the database **18** of server **12**, and making it available to the database server **16**. In some embodiments, the build processor **20** of the database system **16** can retrieve one or more backup images **26** and write them to a different storage area so as to create a new database, rather than writing over the corresponding data in the existing or previous database **18**.

[0035] Client **14** can be any suitable computer system or electronic device that allows a user (or program) to communicate with the server **12**. The client **14** can implement an application **22**, which can be a database interface application, for example. The database interface allows the user to input queries to the server **12** and the database server **16**, to search for data stored in the database **18** that satisfies the queries, and return that data to the application **22**. For example, user access can be provided to the data of the database **18** using a database language, such as Structured Query Language (SQL). In alternate embodiments, interface application **22** can be implemented on the server **12** to allow access to database server **16** for a user.

[0036] The communication between client **14** and server **12** (or application **22** and database server **16**) is allowed over a communication layer **22**, which can include transmission wires, wireless communication devices, internal circuits to the server **12**, or any electronic communication medium and mechanism.

[0037] FIG. **2** is a block diagram illustrating a database **18** suitable for use with the present invention. Database **18** includes one or more table spaces **40**, a recovery history file **42**, and log files **43**.

[0038] Database **18** stores data categorized or structured in a predetermined manner. The data of database **18** can be accessed by users and administrators using an application **22** as described above with reference to FIG. **1**. Users or other computers or programs may also store additional data in database **18** using an interface to the server and database, such as application **22** or other program or device in communication with the database server **16**.

[0039] Table spaces **40** are subsets or subsections of data stored within the database **18**. Herein, the term "table space" refers to a logical storage unit for data which stores data files in the form of tables or other relational database structures. The term "logical storage unit" is intended to refer generally any collection or group of data within a database, regardless of how it is organized. Although the term "table space" is used as an example throughout this description, any group of data in a database can be used with the present invention. Each table space **40** has an allocated storage area defined for it that can be used to store data, where typically the data in a single table space have characteristics related in some way so that access to the table space is more intuitive. For example, all the data in a particular table space could relate to the personal information for employees of a company, while a different table space could store data related to invoices received by the company.

[0040] A table **44** can be provided in each table space **40**, where the table **44** stores the data of the table space in an organized structure. For example, a table storing the addresses and phone numbers for company employees can include a separate column for names, addresses, and phone numbers, with each row of the table corresponding to a different employee. There can be one table, or multiple tables **44** stored in each table space **40**. Other types of relational structures can alternatively be stored in a table space **40**.

[0041] Recovery history file **42** is a file of stored data that includes the history of all backups that have been made of the data in database **18** (as well as other database events). Such details as the particular table spaces **40** that were backed up on each occasion, the time and date of each backup event, the type of backup made (incremental or full), and the destination storage space (storage location) of the backups can all be included in the history file **42**. The recovery history file **42** can be used to recover a stored backup image, as detailed below with respect to FIG. **5**, since the history file **42** has the details as to what data was backed up and when/where it was backed up.

[0042] Log files **43** are files storing records of logs of changes made to the database. When the database processes any workload, log records are written in a log file (and written to the next log file **43** when the first log file fills up, etc.). For example, the user may wish to restore the database data to a point in time after the store date of a backup image; to perform this function, the appropriate records from the log files **43** are "replayed" or applied to the database data after the desired backup images have been restored. In some embodiments of the present invention, there may be restored backup images which were stored at different times, and the log files **43** are used to synchronize the restored data so that all the data restored from the images reflects the same point in time. Thus, the logs are replayed for the oldest image, then later images, up to the point in time that the user wishes to recover, and so on for each image. Once all images are synchronized at the table space time, then any additional changes past that point in time can be applied, if desired, by replaying the appropriate logs. In other embodiments, such as for an offline restoration of a non-recoverable database using an entire database image, the user will only restore up to the time of the backup image, and the log files would not be needed.

[0043] FIG. **3** is a block diagram illustrating one example of storage implementation for database **18**. The storage capability of storage devices **50** can be used to implement the table spaces **40**. Any storage devices can be used, such as hard disks, magnetic tape, optical storage devices (CD, DVD), etc. The allocation of which storage device **50** stores data for which table space **40** is a hardware implementation that varies with different applications, and is well known to those of skill in the art. For example, a single table space **40** can be physically stored on two or more storage devices **50**, as shown in FIG. **3**, or in another embodiment, can be stored on a single storage device. This physical storage layout can be decided on by the user.

[0044] FIG. **4** is a diagrammatic illustration of an example of a backup data image **26** suitable for use with the present invention. Backup image **26** is a copy of data from the database **18** which has been stored separately from the database, e.g., in data storage **21**. If backup image **26** stores table space data needed for a restore operation, the data from the image **26** is copied back into the database **18** over its corresponding data, or is copied to another location to create another database.

[0045] Backup image **26** is stored as a collection of "objects" (e.g., as one or more files or other units) and divided into several different sections for storing different types of data having different purposes for the image. In the example shown, the image **26** first includes a media header **62**, which includes header information indicating the start of the image to a scanning process, a description of the image, and the environment (such as computer or operating system platform, bit size, etc.) to which the database belongs. Following the media header, an initial meta data field **64** holds "description information" related to the database **18** (among other information not relevant to this invention), where the description information includes table space definitions **70**, a table space inventory list **72**, and a copy of the recovery history file **42**.

[0046] Table space definitions **70** are configuration data which state the structural layout and the storage requirements for each table space **40** in the database **18**, including the table space(s) stored in image **26** in which the definitions are stored, at the time that the backup image **26** was stored. Each table space **40** has its own table space definition included in the definitions **70**. Table space definitions **70** indicate how the table spaces **40** are laid out in the database **18**, so that any particular table space stored in a backup image **26** can be stored in the correct location and linked to the database in the proper way to recreate the database. The definitions also store information about the recovery points in time, such as consistency points and information related to log transactions (e.g., starting values that mark where replaying of logs would take place from), etc. Table space definitions **70** also state the storage requirements (in terms of data space) for all the table spaces **40**, so that a build process knows how much space to allocate for a table space that is to be restored. The table space definitions also indicate where the storage paths are for all the user data of the table spaces **40**, including the access path to the table spaces, etc. The current table space definitions **70** are written to each image **26** when each image is backed up; thus, the table space definitions in a particular backup image **26** describe the table space structure of the database **18** at the time that the particular image **26** is stored.

[0047] The table space inventory list **72** is a list of all the table spaces **40** in the database (at the point in time when image **26** was stored), and also includes a flag, marker, or other indication for each of the table spaces as to whether that table space has user data that is included in the backup image **26** that stores the list **72**. This list is used in the determination of backup images to restore, as described below with reference to FIG. **5**. In other embodiments, the data of list **72** can be combined with the table space definitions **70**.

[0048] As described above, the recovery history file **42** stores backup image information for all the table spaces **40** in the database **18**. Whenever a backup is performed from the database **18**, one or more entries are written in the recovery history file **42** that indicates when the backup was performed, and which table spaces (user data **66**) were backed up in which backup images. Since the history file **42** includes the backup information for all the table spaces **40** of the database, a recovery history file **42** is stored in every image **26** of a table space **40** of the database **18**. The recovery history file **42** is accurate up to a time just before the file is backed up by the current image.

[0049] User data **66** is the actual copy of data from one or more table spaces **40** as stored in the particular backup image **26**. User data **66** can be in the form of tables or other organizations or collections of data. Typically, the data **66** is related to each other in some fashion, so that the image **26** stores a particular type of data or other identifiable collection of data. One backup image **26** may store one or more complete table spaces, or only portions of one or more table spaces **40**. If the backup image **26** includes data for an incremental backup, then that incremental user data **66** might only be stored as a portion of data, e.g., as a portion of a table to be added to a previous referenced backup image, or as changes to a referenced table space in a previous backup image.

[0050] End meta data field **68** is provided at the end of each image **26** to signify the end of the user data **66** and the end of the image **68**. The end meta data field also includes a log file header (LFH) **74**, which is a control file for all the log records in log files **43** that make up the database and is thus a snapshot of the state of the database at the time the image is backed up. During a restore operation, the LFH from the oldest restored image is restored, so that after all the backup images are restored, replaying the log files can be performed (if needed) to gain consistency among data from multiple restored backup images, and the LFH from the oldest image provides a correct starting point for the log replays.

[0051] FIG. **5** is a flow diagram illustrating a method **100** of the present invention for building a complete or partial database from backup data images. Method **100** can be implemented, for example, on the same computer or electronic device (or one of the computer systems or devices) that implements the database server **16** and database **18**. For example, the build processor **20** of the database server of FIG. **1** can implement the method. Method **100** can be implemented by program instructions or code. Program instructions can be stored on a computer readable medium, such as memory, hard drive, other magnetic disk, optical disk (CD or DVD), etc. Alternatively, the method **100** can be implemented in hardware (logic gates, etc.), or in a combination of hardware and software.

[0052] The method begins at **102**, and in step **104**, there is identified a target backup image and a list of table spaces which are desired to include in a built database. The desired built database may be an existing database, where the list of table spaces are intended to be written over the corresponding table spaces in the existing database. Or, the built database can be a new, created database.

[0053] In one embodiment, the target image is identified when a user (e.g., user, other software program, etc.) can specify the target image and list of table spaces to the database server **16** and build processor **20**, via an application **22** or by other inputs. In another embodiment, a user can input a particular point in time in the past to which the user wishes the database to be built, and the list of desired table spaces, and the method **100** would then automatically find and specify a backup image to use as the target image, e.g., the most recent backup image available, or closest in time and previous to the user's specified point in time.

[0054] The target image is a backup image **26** (where the image is collection of data/information objects having all been backed up at the same point in time). The target image, in the described embodiment, includes a copy of at least one of the table spaces **40** from the database **18** which the user is interested in including in the built database. The target image can be an image of the entire database, or an image of a subset of the database (table spaces). The target image was originally stored at a particular date and this image has been chosen by the user as having a desired restoration date, the baseline date for the built database. For example, the user may wish to restore the database (or a subset of table spaces) that existed at a particular desired point in time in the past. Assuming that there are different images of table spaces stored at different points in time in the past, the user preferably selects as the target image a backup image **26** having a store date closest in time before the desired point in time. Thus, if the user wishes to restore the database to its state as it existed two weeks ago, the user would preferably select as the target image the data image backed up before, and closest in time, to the desired time two weeks ago. In other applications, the user could select an image having a backup date further back in time.

[0055] The user also identifies a list of table spaces in step **104**. This list designates which table spaces **40** the user wishes to include in the built database. Thus, if the user specifies all the table spaces **40**, then the entire database **18** will be restored (a complete database). If the user identifies a subset of table spaces **40**, then only those tables spaces are restored, creating a partial database. (In some embodiments, the table spaces **40** of the existing/previous database that are not in the list can be made inaccessible after restoration, but need not be deleted from the existing database, in case the user wishes to access them at some later time.) It should be noted that, according to the present invention, the built database results from a "database-level" restore operation. All the configurations and structures of the entire database will be restored for the built database, even when the built database is a partial database having only a subset of the user data from the database. The present invention allows the restoration of an entire database structure having only a subset of the actual data.

[0056] Thus, when specifying the target image and list of desired table spaces of step **104**, the user has several different options according to the present invention, allowing much greater flexibility in restore operations. For example, the user may specify that the target image is a complete database image, and specify in the list only a subset of the data from the image (resulting in a partial database-level database). Or, the user may specify a target image having only a subset of database data, and specify in the list all the data of the database, resulting in a complete database restored from individual table space images stored at different times. The user may also specify a target image having a subset of data, and specify in the list a subset of data, resulting in a partial database.

[0057] In one embodiment, the target image will include a catalog table space of the database, or the list of desired table spaces will specify the catalog table space for inclusion in the built database. The catalog table space is a main table space in the database that includes control information that deals with basic database functionality and is required to use the database, and thus must be included in the built database. If the catalog table space is not included in the target image and is listed in the user's list, then it is restored as a remaining backup image as detailed below. In some embodiments, the catalog table space may not be present in either the target image or the list of desired table spaces; in such a case, the method **100** can be performed as usual, but the resulting built table space will not be accessible by a user until the catalog table space is (later) restored for the database, e.g., in a standard table space restore operation. In another embodiment, the method **100** can automatically halt if no catalog table space is found in the target image and list, and prompt the user for additional confirmation and/or input. In other embodiments, such as when the database is a non-catalog partition, there may be no catalog partition to restore.

[0058] In step **106**, the process restores all the table space definitions in the initial meta data field **64** of the target image so that they may be used (e.g., the process writes the definitions to the existing database, overwriting the existing definitions). Since they are from the target image, the restored table space definitions describe the table space structure of the database **18** at the time at which the target image was stored.

[0059] In step **108**, the process determines a list of table spaces from the target image to restore to the built database. These are the table spaces which have user data in the target image and which are included in the list of desired table spaces from step **104**. This step includes using the restored table space definitions **70** and the table space inventory list **72** of the initial meta data **64** in the target image and parsing/reducing down the list of table spaces provided by the user in step **104**, to those table spaces that have user data in the target image. Those table spaces that have user data in the target image have their table space storage (e.g., in the existing/previous database) acquired and allocated at this time. For example, a user provides in step **104** a target image and a list of five table spaces to restore to the built database, and only three of those table spaces have user data in the target image. The table space definitions for all five table spaces are restored in step **106**, and the list generated in step **108** is the result of parsing the five table spaces down to three so that it is known which table space data to restore out of the target image.

[0060] In step **110**, the process checks whether there are any table spaces to restore resulting from step **108**. This is an error checking procedure for the described embodiment that makes sure that at least one table space from the target image is to be restored. If no table spaces are found in the target image which are to be restored, then the process continues to step **112** to implement and/or indicate an error, and the process is complete at **132**. In an alternate embodiment, step **110** can be removed, and the target image need not include any table spaces to be restored.

[0061] If there are table spaces in the target image to restore, then the process continues to step **114**, in which the user data for the table spaces from the target image is restored. The user data **66** is retrieved from the target image and copied to the current database storage in the table space corresponding to the data, or to a newly-allocated or created table space.

[0062] It should be noted that if the target image holds incremental backup data, then the table spaces are not restored in step **114**, and steps **108**, **110**, and **114** are skipped, so that the earlier, full base data for the incremental data can be retrieved from an earlier backup image and the incremental changes applied to it in steps **116**-**128**, detailed below.

[0063] In step **116**, the process determines a list of table spaces which are not included in the target image and which still need to be restored to the built database. These are table spaces identified in the list step **104**, which were not in the target image. If the user is restoring the entire database, then the table spaces of step **116** are all of the remaining table spaces in the database besides the restored table spaces of step **114**. If the user is restoring only a partial database, then the remaining table spaces are a subset of all remaining table spaces in the database.

[0064] In step **118**, the process checks if there are any remaining (non-target-image) table spaces to restore. For example, if the user only wishes to restore the table spaces in the target image and no other table spaces, then there will be no more table spaces to restore after step **114**; the process then continues to step **130**, detailed below. If there are remaining table spaces to restore, then the process continues to step **120**, where the process scans the recovery history file **42** of the database **18** to determine a list of all existing stored backup images that include these remaining table spaces. In some cases, there may be multiple similar backup images found in step **120**, each of those backup images including data for the same particular table space at a different point in time. The recovery history file was processed as part of the initial meta data **64** in the target image, and after the target image is restored, the history file is up to date, including for the target image. In one embodiment, the history file from the target image is restored to the database **18** only if the existing history file is corrupted, empty, etc. In an alternate embodiment, the history file in the target image is always restored and replaces the existing history file.

[0065] In step **122**, the process sorts the list of the backup images from step **120** chronologically, based on the time at which those backup images were stored, i.e., from the oldest image to the most-recently stored image. The oldest images are sorted to be first so that any incremental backups can be applied in the proper chronological order, from the oldest image to the newest incremental changes.

[0066] In step **124**, the process scans the chronologically-ordered list of backup images from step **122** to determine the correct restore sequence and the correct list of table spaces to restore. The correct restore sequence is a sequence that allows the table space allocated storage to be accurately prepared for the restored user data. For example, if incremental backups were performed with one or more of the desired table spaces, those table spaces may need to be modified one or more times with later-stored backup images that include the incremental changes to earlier images. The correct restore sequence is the correct, chronological incremental restore sequence which allows the process to allocate table space storage for the restoration of the incremental images. The allocation of storage space needed for the restored table spaces can be figured by looking at the multiple backup images from an incremental backup, each in turn and in the proper sequence, where the proper order of restoration is provided from oldest image to newest incremental image. To adhere to the required restore sequence across multiple table spaces from different points in time, the table space storage is properly identified in advance, before the actual restoration of steps **126** and **128**.

[0067] The correct list of table spaces to restore includes those remaining non-target-image table spaces identified in the list provided in step **104**, where older versions of (non-incremental) backup images have been discarded in favor of corresponding earlier versions. Redundant incremental images, if any, are discarded as well.

[0068] In step **126**, the process checks whether there are any remaining backup images to restore to the built database. If so, then the process continues to step **128**, where the next backup image in the correct list of backup images from step **124** is restored to the built database. The restoration might include copying the data in the backup image to the database **18** in place of any equivalent data that already exists in the database, or to a new allocation of storage space. When restoring a backup image, only the desired table spaces are requested and restored from the image. The process then returns back to step **126** to check if there is another backup image to restore from the corrected list.

[0069] After all the backup images from the list are restored via steps **126** and **128**, then the process continues to step **130**, where the logs for the restored data are replayed. As explained above, the log files **43** hold records with information that will restore (update) the database past the time of a backup image. The LFH **74** stored in each image includes log file information used in this step to determine the starting point for the replaying of the logs for full restoration. In the present invention, the logs are used to synchronize the data from different backup images. Since the present invention allows images from different times to be combined and used in restoring a database, the data from these images must be synchronized to a consistent point in time, such as the latest image restored. For example, they can be synchronized up to the time of the target image if the target image is the latest image restored. The replaying of the logs updates the data from the images to the time of the latest image. In addition, the logs can be similarly used to update the restored data to a desired point in time after the date of the latest image restored.

[0070] The process is then complete at **132**.

[0071] In one embodiment, the user can be allowed to provide input for several options before step **130** is processed. For example, the user can be asked if he or she wants to restore another table space into the database using the standard table-space level restoration process, before the replay logs are replayed (e.g., this option can be used to restore a catalog table space if it was not already restored). After step **130**, when the process is complete and the database has been built, the user can be allowed to connect, or prompted whether they want to connect, to the built database. The user can also restore individual table spaces to the built database at a later time using a standard table-space level restore process, e.g., to restore less critical table spaces when time permits.

[0072] The present invention advantageously allows an administrator to restore an entire database using a set of backup data images that were backed up at different points in time. Thus, the entire database can be restored without ever having backed up a full database image at one time in the past. Administrators therefore need not always perform lengthy full database backups, and can restore databases from individual table space backups performed at different times.

[0073] The present invention also allows an administrator of a database system to specify a subset of database data, such as particular table spaces, that the administrator wants to include in a built database, and the system will automatically find the desired table spaces of data and restore only those table spaces to a database-level, partial database. This capability is not present in prior systems, in which the entire database with all its data must be restored. Thus, the present invention allows data administrators to decide on the order in which table spaces are restored and recovered for a database-level restoration, so that critical table spaces can be recovered in a timely manner, and the recovery of less important table spaces can be delayed until time permits.

[0074] Although the present invention has been described in accordance with the embodiments shown, one of ordinary skill in the art will readily recognize that there could be variations to the embodiments and those variations would be within the spirit and scope of the present invention. Accordingly, many modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the appended claims.

What is claimed is:

1. A method for building a database from stored data images, comprising:

receiving an identification of a target image, wherein the target image includes a copy of at least one logical storage unit of data from a previous database, and description information that describes the previous database, wherein the target image holds a copy of a subset of the data of the previous database;

receiving a list of at least one desired logical storage unit of data to be included in a built database, wherein the at least one desired logical storage unit is from the previous database; and

restoring the at least one desired logical storage unit from at least one stored data image to the built database using the description information in the target image.

2. The method of claim 1, wherein the logical storage units are table spaces.

3. The method of claim 2, wherein at least one of the desired logical storage units is included in the target image and is restored from the target image to the built database, wherein the at least one stored data image is the target image.

4. The method of claim 3, wherein the description information includes a set of table space definitions describing the table space structure of the previous database, and wherein the restoring of the at least one desired table space includes using the set of table space definitions in the target image to determine a table space structure for the built database.

5. The method of claim 4, wherein the list includes a plurality of desired table spaces, wherein the target image does not include all of the desired table spaces for the built database, and wherein the description information includes a recovery history file describing stored backup images of data, wherein at least one of the backup images includes at least one of the desired table spaces which is not in the target image.

6. The method of claim 5, wherein the restoring of the at least one desired table space includes scanning the recovery history file to determine desired backup images that include desired table spaces not included in the target image, and restoring the determined desired backup images to the built database.

7. The method of claim 6, wherein at least one of the desired backup images was stored at a different point in time than the target image.

8. The method of claim 7, further comprising sorting the desired backup images chronologically according to the time at which they were stored, and wherein the chronological ordering is included in the restoration of the desired backup images to the restored database, the desired backup images being restored one at a time to the built database.

9. The method of claim 5, wherein at least one of the desired backup images includes a copy of incremental data relative to a different previous backup image, the incremental data resulting from an incremental backup of data.

10. The method of claim 3, wherein the built database is a complete database including all of the table spaces of the previous database.

11. The method of claim 3, wherein the built database is a partial database including only a subset of the table spaces of the previous database accessible to users, and wherein the list of desired table spaces specifies only the subset of table spaces.

12. The method of claim 5, further comprising replaying log information to update the data restored from the desired backup images and synchronize the data from the desired backup images with the data from the target image.

13. A method for building a database from stored data images, comprising:

receiving an identification of a target image, wherein the target image includes a copy of at least one logical storage unit of data from a previous database, and description information that describes the previous database, wherein the target image holds a copy of a subset of the data of the previous database;

receiving a list of at least one desired logical storage unit of data to be included in a database-level built database, wherein the at least one desired logical storage unit is from the previous database and is a subset of data from the previous database; and

restoring the at least one desired logical storage unit from the target image to the built database using the description information in the target image.

14. A computer program product comprising a computer readable medium including program instructions for building a database from stored data images and to be implemented by a computer system, the program instructions for:

receiving an identification of a target image, wherein the target image includes a copy of at least one logical storage unit of data from a previous database, and description information that describes the previous database, wherein the target image holds a copy of a subset of the data of the previous database;

receiving a list of at least one desired logical storage unit of data to be included in a built database, wherein the at least one desired logical storage unit is from the previous database; and

restoring the at least one desired logical storage unit from at least one stored data image to the built database using the description information in the target image.

15. The computer program product of claim 14, wherein the logical storage units are table spaces, and wherein at least one of the desired logical storage units is included in the target image and is restored from the target image to the built database, wherein the at least one stored data image is the target image.

16. The computer program product of claim 15, wherein the description information includes a set of table space definitions describing the table space structure of the previous database, and wherein the restoring of the at least one desired table space includes using the set of table space definitions in the target image to determine a table space structure for the built database.

17. The computer program product of claim 15, wherein the built database is a complete database including all of the table spaces of the previous database.

18. The computer program product of claim 15, wherein the built database is a partial database including only a subset of the table spaces of the previous database accessible to users, and wherein the list of desired table spaces specifies only the subset of table spaces.

19. A system for building a database from stored data images, the system comprising:

a database for storing a built database;

data storage that stores a target image, wherein the target data image includes a copy of a table space of data from a previous database, and description information that describes the previous database, wherein the target image holds a copy of a subset of the data of the previous database; and

a build processor in communication with the database and the data storage, the build processor operative to receive an identification of the target image and a list of at least one desired table space of data to be included in the built database, wherein the at least one desired table space is from the previous database, wherein the build processor restores the at least one desired table space from a stored data image to the built database using the description information in the target image.

20. The system of claim 19, wherein the stored data image is the target image, wherein the description information includes a set of table space definitions describing the table space structure of the previous database, and wherein the restoring of the at least one desired table space includes using the set of table space definitions in the target image to determine a table space structure for the built database.

21. The system of claim 20, wherein the list includes a plurality of desired table spaces, wherein the target image does not include all of the desired table spaces for the built database, and wherein the description information includes a recovery history file describing stored backup images of data, wherein at least one of the backup images includes at least one of the desired table spaces which was not in the target image.

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