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(71) Applicant *(for all designated States except US)*: **SANDISK IL LTD.** [IL/IL]; Central Park, 7 Atir Yeda, 44643 Kfar Saba (IL).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **GOLDE, Ittai** [IL/IL]; 62A Bilu St., 75321 Rishon Letzion (IL). **BEN ZVI, Kobi** [IL/IL]; Hasharon Street 23, 47240 Ramat-Hasharon (IL). **VEXLER, Oron** [IL/IL]; Rachavat Ilan 4A/15, 54056 Givat Shmuel (IL). **POMERANTZ, Itzhak** [IL/IL]; 18 Golomb Street, 44357 Kfar Saba (IL).

(74) Agent: FRIEDMAN, Mark; Moshe Aviv Tower, 54th Floor, 7 Jabotinsky Street, 52520 Ramat Gan (IL).

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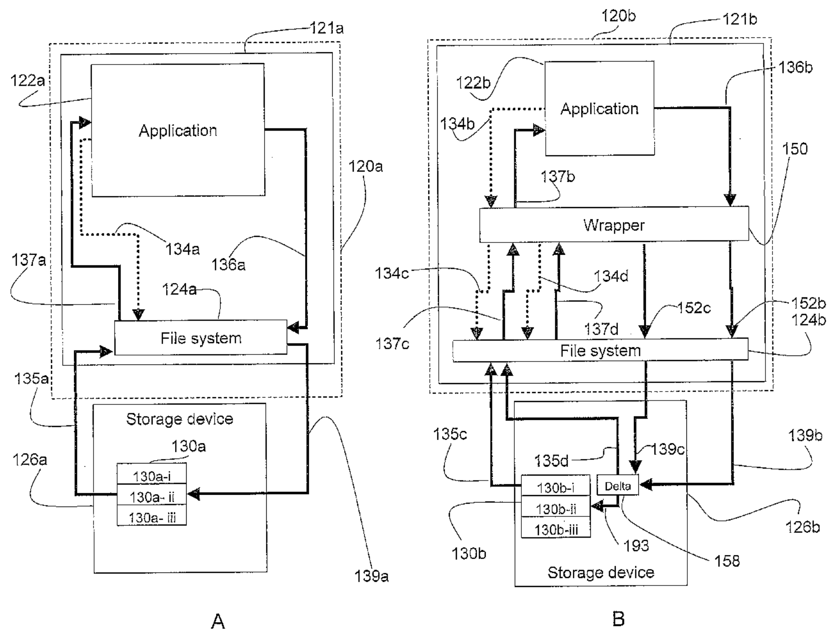

(57) Abstract: A system and method to protect a target file from data damage wherein a wrapper application transparently intercepts a write call operative to affect the target file and stores the pertinent data in a delta file. Occasionally the target file is backed up in a temporary file and then updated. The wrapper application also intercepts a read call operative to access the target file and merges the update information with data from the target file in a temporary file. The resulting merged data is returned as read results data.

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INCREMENTAL TRANSPARENT FILE UPDATING

FIELD AND BACKGROUND OF THE INVENTION

Various methods and systems to protect a target file from damage are possible, and particularly, methods and systems may prevent data damage that occurs due to disruption while the target file is open for writing.

Flash memory devices are very well known in the art of computer engineering.

The normal way of storing information in such memories is in data files that are managed by the operating system.

It is a known property of flash storage systems that a data file is vulnerable to data damages if certain unexpected events, such as power failures or software crashes, occur while the file is open for writing. This poses a severe problem because writing into a file is routinely necessary, and a file must be open for writing in order for it to be updated.

Solutions have been developed for software applications to handle files in special ways that reduce the risk. Such solutions can be seen in many word processing applications, which periodically makes a backup copy of open files. Alternatively, a fix utility runs post-effect, when corruption of the file has been detected. However, such solutions are application dependent, slowing down the development of applications, and are a source of other types of problems due to programming errors. Furthermore, when a running application is protecting an original version of a file and also keeping an updated temporary copy, there arises a problem of access conflicts (if a different application calls the file, which file will it access?). This requires inconvenient locking of files. Protection methodologies are also available for system-wide file protection schemes, which constantly update permanent backup copies of an entire data storage device or particular important data. Keeping a permanent back up requires significant data storage space and system resources to constantly check and update files.

There is thus a widely recognized need for, and it would be highly advantageous to have, a solution that allows any application to use any data file without the risk that the file will be damaged due to the above-mentioned causes and without keeping a permanent back up copy.

SUMMARY OF THE INVENTION

Various methods and systems to protect a target file from data damage are possible, and particularly, methods and systems may prevent data damage that occurs due to disruption while the target file is open for writing.

An embodiment of a system for storing a target file and protecting the target file from data damage may include: a) a processor configured to retrieve and execute program code of a wrapper application including: i) code for intercepting at least one file command issued by a second application, the at least one file command being operative to affect the target file, ii) code for saving update information pertinent to the at least one file command, and iii) code for updating the target file with the update information; b) a first memory space for storing the target file, and c) a second memory space for storing the update information. The wrapper application may be independent from the second application issuing the file command.

In an embodiment of a computer readable storage medium having computer readable code embodied thereon, the computer readable code for protecting a target file from data damage, the computer readable code may include: a) program code for intercepting at least one file command issued by an application and operative to affect the target file; b) program code for saving update information pertaining to the at least one file command without modifying the target file, and c) program code for updating the target file with the update information. The computer readable code may be independent of the application issuing the command.

An embodiment of a method of employing a wrapper program to protect a target file from data damage, may include the steps of: a) intercepting by the wrapper program of at least one file command operative to affect the target file and issued by an application, the step of intercepting being transparent to the application; b) saving update information pertaining to the at least one file command without altering the target file, and c) updating the target file with the update information.

An embodiment of a system for reading data from a protected target file may include a processor configured to retrieve and execute program code of a wrapper application including: code for intercepting at least one file command issued by an application independent of the wrapper application, the file command operative to access the protected target file, and code for reading update information pertaining to the file command. The system may also include a first memory space for storing the protected target file and a second memory space for storing the update information.

An embodiment of a method of employing a wrapper program to read a protected target file may include the step of: intercepting by the wrapper program of at least one file command issued by an application, the file command operative to access the protected target file. The step of intercepting may be transparent to the application. The method may also include the step of reading from a delta file update information pertaining to the at least one file command. The delta file may be separate from the protected target file. The method may further include the steps of merging data from the target file with the update information and returning the merged data as a response to the file command.

An embodiment of a system for storing a target file and protecting the target file from data damage may include a first memory space for storing the target file. The system may also include a second memory space for storing update information pertaining to at least one file command operative to affect the target file. The system may also include a processor configured to retrieve and execute program code of a wrapper application including code for intercepting the at least one file command operative to affect the target file, code for saving the update information to the second memory space and code for updating the target file with the update information. The wrapper program may be independent of the application issuing the file command.

In the system for storing a target file, the first memory space may reside in a nonvolatile memory of a data processing device. In some embodiments of the system, the second memory space may reside in the same nonvolatile memory as the first memory space, with the target file and the update information being stored in separate locations in the memory. In other embodiments, the second memory space may reside in a volatile memory of the data processing device. In other embodiments, the second memory space may reside in a memory (volatile or nonvolatile) of a data storage device.

In the system for storing a target file, the first memory space may reside in a nonvolatile memory of a portable data storage device. Examples of portable data storage devices include a removable medium (for example a magnetic disk or an optical disk) or a portable drive (for example a flash disk, an external hard drive or a smart-card). In some embodiments, the second memory space may reside in the same memory as the first memory space, with the target file and the update information being stored in separate locations in the memory. In other embodiments, the second memory space may reside in a memory (volatile or nonvolatile) of a data processing device. In other embodiments, the second memory space may reside in a volatile memory of the portable data storage device.

In the system for storing a target file, the update information may include only data pertaining to the at least one file command. Particularly, the update data, the second memory space and the delta file may not contain data copied from the target file. Thus, even after a command issued by the application and operative to affect the target file has been stored, there would remain only one copy of the data in the target file (the copy of the data of the target file is stored only in the first memory space) and one copy of the update information pertinent to the stored file command (the data pertinent to the stored file command is stored only in the second memory space). Only after a merge event would a second copy of data from the target file be placed into a temporary file.

An embodiment of a system for storing a target file may further include a third memory space for storing a temporary file and the wrapper application may further include code for copying at least part of the target file into the temporary file. In alternative embodiments, the temporary file is an independent file or a temporarily allotted location in an existing file or a temporarily allotted location in a volatile memory. The wrapper application may also further include code for applying the stored update information to the temporary file to produce an updated version of the target file. The wrapper application may also further include code for replacing part of the target file with the temporary file. According to an alternative embodiment the third memory space may reside in the same memory as the first memory space. In another alternative embodiment the third memory space may reside in the same memory as the second memory space. In a further alternative embodiment, the third memory space may reside in any one of the memories listed above. Thus, it is understood that the third memory space could reside in a volatile or nonvolatile memory of a data processing device or of a data storage device and each alternative location for the third memory space may be in combination with each of the alternative locations of the first and second memory spaces.

An embodiment of a computer readable storage medium having embodied thereon computer readable code for protecting a target file from data damage may include program code for intercepting at least one file command issued by an application, the program code being independent from the application issuing the file command. In an embodiment described below, the program code can be executed separately from any particular application and intercepts file commands from an arbitrary application. The file command is operative to affect the target file. Program code may also be included for saving update information pertaining to the file command without modifying the target file and for updating the target file with the update information. In alternative embodiments, the code may specify that the updating is to be carried according to a fixed time schedule or that the updating is to be carried out in response to one or more termination events or that the updating is to be carried out according to a combination of a fixed time schedule and one or more termination events. Examples of a computer readable medium may include, a ROM contained in a portable storage device or a removable media (for example a CD) included in a package sold with a storage device. Alternatively, the computer readable medium may be a hard disk installed on a server accessible over the Internet. The program code may serve as a stand-alone program to protect data on one or more arbitrary storage devices. Alternatively, the code may be included in a driver program for execution on a data processing device, the driver program serving as an interface between the data processing device and a data storage device. Alternatively the code may be incorporated into an operating system or into a file server application. In a further possible alternative embodiment, the code is executed by a processor internal to a data storage device.

An embodiment of the program code for intercepting the file command and saving the update information may make the intercepting and saving contingent upon one or more conditions. For example the intercepting and saving may be performed only when the application issuing the command is one of a plurality of "included" applications. In the context of the description herein, an "included" application, may be defined as an application that has been designated as one from which the wrapper program is to intercept a file command to modify the target file (generally the included applications are applications that store important files without power out protection [for example Microsoft Visual Studio®]). In an alternative example, the file command may be intercepted and the update information saved if the file command is issued by an application that is not an "excluded" application. In the context of the description herein, an "excluded" application, may be defined as an application that has been designated as one from which the wrapper program is not to intercepts a file command to modify the target file (for example Microsoft Word® may be an excluded application since it has its own automatic file protection or Microsoft Internet Explorer® may be excluded because it saves a large number of temporary files but does not generally save user modified files). In an alternative example, the file command may be intercepted and the update information saved if the file command is operative to affect a file that is not a temporary file. In an alternative example, the file command may be intercepted and the update information saved if the file command is operative to affect a file belonging to an "included" file type. In the context of the description herein, an "included" file type may be a type of file that has been designated to be protected by the wrapper application [for example a .txt file may be an included file type]. In an alternative example, the file command may be intercepted and the update information saved if the file command is operative to affect a file not belonging to an "excluded" file type. In the context of the description herein, an "excluded" file type may be a type of file that has been designated to not be protected by the wrapper application [for example .doc and .tmp file types may be excluded] and in an alternative example, the file command may be intercepted and the update information saved if the file command is operative to affect a file stored in an included storage device. In the context of the description herein, an included device may be defined as a device designated for protection, such that a file on the included device is to be protected.

An embodiment of the computer readable code may further include code to intercept every write command that is operative to affect the target file after the code for saving is executed and until the code for updating is executed.

An embodiment of the computer readable code may further include code for detecting a termination event and for updating the target file with the update information upon detection of the termination event. Some examples of termination events may include an issuing of a command to close the target file, a closing down of an application that accessed the target file, an occurrence of a condition dependent on a statistic related to a plurality of file commands [for example if eighty percent of the file commands issued to the target file change less than 10 Kbytes of data, then a termination event may be triggered when a file command is issued changing more than 10 Kbytes of data in the target file], and an exceeding of a maximum time threshold since a previous updating of the target file.

An embodiment of the computer readable code may further include program code for copying part of the target file into a temporary file, and program code for applying the saved update information to the temporary file. In one alternative embodiment, the code may provide for opening the temporary file and copying the data immediately following the saving of the update information. In a second alternative embodiment, the code may provide for opening of the temporary file and copying of data immediately preceding the updating of the target file.

An embodiment of the computer readable code may further include program code for applying the saved update information to the temporary file upon the occurrence of a merge event.

According to still further features in the described preferred embodiments, Some examples of merge events include: i) an issuing of a command to close the target file, ii) a closing down of an application that accessed the target file, iii) an occurrence of a condition dependent on a statistic related to a plurality of file commands [for example if eighty percent of the file commands issued to the target file change less than 10 Kbytes of data, then a termination event is triggered when a file command is issued changing more than 10 Kbytes of data in the target file] iv) an exceeding of the size of a delta file containing the update information over a maximum size threshold, v) a passing of level of activity of an operating system under a minimum activity threshold, vi) an exceeding of a maximum time threshold since a previous merge event, or vii) an issuing of a command to read the target file, in which case the applying of the saved update information to the temporary file would immediately precede emulation of execution of the read command. Thus, the updated data contained in temporary file would be returned as read information to the application that issued the read command. Alternatively, the applying of the saved file commands to the temporary file may immediately precede the updating of the target file.

According to still further features in the described preferred embodiments, the computer readable code may further include program code for detecting a termination event, and program code upon detection of the termination event for updating the target file with the saved update information and then for deleting the target file or the temporary file or a delta file containing the saved update information.

An embodiment of a method of using a wrapper program to protect a target file from data damage may include the step of the wrapper program transparently intercepting at least one file command operative to affect the target file, the wrapper program being independent of the application issuing the file command, and the step of the wrapper program saving update information pertaining to the at least one file command without altering the target file. The update information may contain the information necessary to execute the at least one file command. The method may also include the step of updating the target file with the update information.

According to still further features in the described preferred embodiments, in the time interval between the start of saving the update information until the end of updating the target file with the saved update information, every write command initiated by an application from a plurality of included applications and operative to affect the target file may be intercepted and saved.

According to still further features in the described preferred embodiments, updating the target file may include the substeps of copying at least part of the target file into a temporary file and applying the saved update information to the temporary file, and replacing all or part of the target file with the all or part of the temporary file, thus effectively updating the target file and deleting the temporary file.

According to still further features in the described preferred embodiments, the delta file containing the update information may be deleted subsequent to the step of applying the stored update information to the temporary file.

According to still further features in the described preferred embodiments, the step of updating may be performed upon occurrence one or more termination events. Examples of termination events include the following: i) an issuing of a command to close the target file, ii) a closing down of an application that accessed the target file, iii) an occurrence of a condition dependent on a statistic related to a plurality of file commands [for example, if for a period of one half hour an application accessed the target file at least once every five minutes, then the application not accessing the target file for a ten minute period is a termination event which triggers updating of the target file], iv) a passing of level of activity of an operating system under a minimum activity threshold, v) an exceeding of a maximum time threshold since the issuing of the previously saved file command, and vi) an exceeding of a maximum time threshold since a previous merge event.

According to still further features in the described preferred embodiments, the steps of intercepting a file command and saving update information may be contingent on a condition. For example intercepting and saving may only occur when the file command is issued by a application from a plurality of included applications, when the file command is issued by a application other than an excluded application, when the file command is operative to affect a file other than a temporary file, when the file command is operative to affect an included file type, when the file command is not operative to affect a file of an excluded file type or when the file command is operative to affect a file stored in an included storage device.

An embodiment of a system for reading data from a protected target file may include a processor configured to retrieve code of a wrapper application from a storage media and configured to execute the code. The wrapper application may include code for intercepting at least one file command issued by an application independent of the wrapper application, the file command operative to access the protected target file. The wrapper application may also include code for reading update information pertaining to the file command. The system may also include a first memory space for storing the protected target file and a second memory space for storing the update information.

According to further features in the described preferred embodiments, the wrapper application of the system for reading from protected target file may also include code for merging data from the protected target file with the update information into a temporary file. The temporary file may be the file containing the update information or the temporary file may be a separate temporary file. The temporary file and the update information may be stored on the same memory device as the target file or on a separate memory device.

An embodiment of a method of employing a wrapper program to read a protected target file may include the step of: intercepting by the wrapper program of at least one file command issued by an application, the file command operative to access the protected target file. The step of intercepting may be transparent to the application issuing the command. The method may also include the step of reading update information pertaining to the at least one file command and stored in a delta file. The delta file may be separate from the protected target file. The method further contains the steps of merging data from the target file with said update information and returning the merged data as a response (the response being the read results data) to the file command.

TERMINOLOGY

The following terms are used in this application in accordance with their plain meanings, which are understood to be known to those of skill in the pertinent art(s). However, for the sake of further clarification in view of the subject matter of this application, the following explanations, elaborations and exemplifications are given as to how these terms may be used or applied herein It is to be understood that the below explanations, elaborations and exemplifications are to be taken as exemplary or representative and are not to be taken as exclusive or limiting. Rather, the terms discussed below are to be construed as broadly as possible, consistent with their ordinary meanings and the below discussion.

- Merging: The process of, e.g., applying update information saved in a delta file to content copied from a target file into a temporary file (for example the temporary file may be the delta file or a separate temporary file).
- Merge Event: An event that triggers a merging process. The event may be based on operating system events, such as a time base, a file system operation, or an indication from the wrapper application.
- Updating a target file: The process of applying update information to the target file (see above). In a preferred embodiment (below), updating the target file is performed by copying a part of the target file to a temporary file, applying update information to the temporary file and replacing the part of the target file with the corresponding updated data in the temporary file.
- Delta File: A temporary file that may be used for, e.g., accumulating update information related to intended changes in a target file.
- Target File: A file that is the intended object of some action, operation, process etc., whether or not the file is in fact acted upon, affected, etc. Herein, "target file" may be used to refer to a file to be protected from data damage.
- Interception: The process of monitoring, checking, altering and/or redirecting communications, e.g., between an application and a file system or between an application and an operating system.

- Independent application: a first application is said to be independent of a second application if the first application is not contingent on the second application, i.e., does not require the second application in order to function as intended.
- Wrapper: An application that monitors, intercepts and/or controls communications, e.g., between another application and the computer system or between one or more applications and a device.
- Data storage device: A mechanism that is employed, e.g., by a data processing device to store data and from which data can be retrieved. A data storage device may be installable (for example a hard disk) or removable (for example a flash disk) or a removable medium (for example a compact disk or a magnetic tape).
- Storing a command: For the sake of the current application, "storing a command in a delta file" may be used to refer to the operation of storing in the delta file update information pertaining to the command, the update information containing data necessary to apply the command at a future time.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of a system and method for protecting a file from data damage are herein described, by way of example only, with reference to the accompanying drawings, where:

Figure 1A is a schematic illustration of a prior art file storage system;

Figure 1B is a schematic illustration of a first embodiment of a system for storing and protecting a target file;

Figure 2 is a schematic illustration of a second embodiment of a system for storing and protecting a target file;

Figure 3 is a flow chart illustrating interception and redirection of a read command and emulation of reading a target file;

Figure 4 is a flow chart illustrating applying update information to a temporary file, and

Figure 5 is a flow chart illustrating the process of intercepting and redirecting a write call to a target file.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principles and operation of incremental transparent file updating according to various embodiments may be better understood with reference to the drawings and the accompanying description.

Various preferred embodiments exemplify a system that minimizes the risk of damaging a data file by minimizing the time that the file is kept open for writing, thus minimizing the risk that an unexpected event will occur while the file is open.

According to the preferred embodiments, applications implement read and write commands operative to access a protected data file (the target file), while the target file remains opened for reading only – a process that does not place the file at risk. A small service storage area, hereinafter called a delta file, is kept open and is used to store update information pertinent to file commands operative to affect one or more data files (target files) by one or more applications. Meanwhile reading and writing to the target file is emulated by a wrapper application. The wrapper application launches, monitors, intercepts and emulates basic elements in the communication between a functional application and a device or between a functional application and an operating system. Particularly, all the update information is accumulated in one or more delta files. When necessary (for example in order to emulate a reading the updated target file or as preparation for updating the target file) the stored update information and data read from the target file are merged into a temporary file. In the merge process, the temporary file is opened for writing and part or all of the target file is copied to the temporary file. The wrapper application then updates the temporary file based on the update information stored in the delta file.

Occasionally, the target file is also updated. When updating the target file, first the temporary file is closed and checked. Then part of the target file is replaced by the temporary file. This process protects the target file from data damage by minimizing the time that the target file is open and vulnerable to data damage. Furthermore, if a power failure occurs while the target file is being copied to the temporary file, then the target file remains intact. If a power failure occurs while part of the target file is being updated, the temporary file remains intact.

Both the file system and the functional application are blind to this wrapping process, which is transparent to both. The functional application functions exactly as when there is no wrapper application. The file system handles all file commands that reach the file system exactly as when there is no wrapper application.

Thus, a functional application programmer writes his program according to operating system standards without need to adapt the program for or even be aware of the file protection routine. Likewise, the programmer does not need to devise an application dependent routine to prevent data damage due to interruption while writing to storage.

Because the functioning of the wrapper program is transparent to the functional application and to the file system, the wrapper program can function independently of any particular functional application. Thus, the wrapper program can be sold separately as a stand-alone program for protecting files accessed by an arbitrary functional application. Since the wrapper program is independent of any particular functional application, the wrapper program can be included in a device driver or in an operating system that must respond to commands from any program that a user may install.

Figure 1A shows a prior art data processing device **120a** (such as a personal computer), having a processor **121a**. Processor **121a** is executing an application **122a** (such as the Microsoft Windows® Notepad text editor) and a file management system **124a** (such as FAT32 or NTFS). Application **122a** and file management system **124a** are illustrated inside of processor **121a** to indicate that processor **121a** is executing them.

Application **122a** issues a file command, for example a read call **134a** operative to access a file **130a**. File **130a** is stored in a portable data storage device **126a**. Read call **134a** is processed directly by file management system **124a**. File management system **124a** opens file **130a** for reading and reads **135a** data from file **130a** and sends **137a** the data to application **122a**. At a later time, application **122a** issues a second file command, a write call **136a** operative to affect file **130a**. As is known to those skilled in the art, a file does not generally reside in a single continuous set of memory addresses, but consists of a string of parts whose addresses are associated by a set of memory address pointers. Particularly file **130a** is composed of three sections **130a-i**, **130a-ii**, and **130a-iii**. When modifying a file it may be necessary to add information that does not fit in the memory currently allocated to the file. In such a case, it is not necessary to move the entire file to a new memory range, rather a new address is associated to the file and the new data are written in the new memory space. File management system **124a** receives write call **136a**, opens file **130a** for writing and writes **139a** data directly to file **130a**. Such is the state of the art.

It is well known that valuable data can be lost from open files when a disruption occurs (for instance a power failure, or removal of portable data storage device **126a** from a socket, or a software failure) while writing to a device such as portable data storage device **126a**. Thus, file **130a** of the system of Figure 1A is in grave danger of data loss whenever an application such as application **122a** issues a write command such as write command **136a**.

Figure 1B shows a first embodiment of a system for incremental transparent file updating, including a data processing device **120b** (such as a personal computer), which contains a processor **121b** running an application **122b** (such as the Microsoft Windows Notepad text editor), a wrapper application **150** (also being executed on processor **121b**), and a file management system **124b** (such as FAT32 or NTFS). Application **122b** and wrapper application **150** are represented in Figure 1B inside of processor **121b** to indicate that application **121b** and wrapper application **150** are being executed by processor **121b**.

Application **122b** issues a file command, for example a write call **136b** operative to affect a file **130b** stored on a mobile storage device **126b**. Application **122b** is a standard application and all file commands (including write call **136b**) are issued according to standard operating system protocols.

Target file **130b** consists of three parts marked **130b-i**, **130b-ii**, and **130b-iii**. Each part **130b-i**, **130b-ii**, and **130b-iii** occupies a continuous string of memory addresses. The last byte of each parts **130b-i** and **130b-ii** is a pointer that points to the first address of the next part of target file **130b**. The last bit of part **130b-iii** is a stop bit representing the end of file **130b**. Write call **136b** is intercepted by wrapper application **150.** In this example, write call **136b** is operative to affect part **130b-ii.** When wrapper application **150** detects write call **136b** then wrapper application **150** checks to determine if write call **136b** is to be intercepted and redirected. In the example of the embodiment of Figure 1B, intercepting and redirecting write call **136b** is contingent on fulfilling all of the following conditions: storage device **126b** being of a type included amongst storage device types to be protected and the type of file **130b** being included amongst file types to be protected. Since, in this example, during set up of wrapper application **150** a user specified that all portable storage devices should be protected and since the driver routine of portable storage device **126b** defines portable storage device **126b** as a portable storage device, therefore portable storage device **126b** is an included storage device. Similarly, file **130b** is of an included file type (a .txt file) therefore wrapper application **150** intercepts and redirects write call **136b**.

Interception of a system call can be done in many ways known to those skilled in the art of programming as described in detail in computer programming text books such as "Loadable Kernel Module Programming and System Call Interception" by Nitesh Dhanjani and Gustavo Rodriguez-Rivera published in the Linux Journal 2006. Particularly, Wrapper application **150** prevents direct transmission of write call **136b** to file management system **124b**. Instead, wrapper application **150** instructs **152b** file management system **124b** to save update information pertinent to write call **136b** in a delta file **158**. File management system **124b** writes **139b** to delta file **158** the update information that is necessary to update target file **130b**. In the example of Figure 1B, update information includes data to add to target file **130b**. It will be understood that update information may be editing information (for example instructions to move a piece of data from one location to another location within target file **130b** or instructions to remove a piece of data from target file **130b**) in which case it update information may include no new data for target file **130b**. Alternatively, if delta file **158** does not exist, file management system will first create delta file **158** before writing **139b** the data. Wrapper application **150** reports back to running application **122b** as if target File **130b** has been updated, thus emulating writing to target file **130b**. During the emulated writing process, all writing has been to delta file **158**. Target file **130b** has not been modified and target file **130b** has not even been opened for writing. It is emphasized that wrapper application **150** receives file commands according to standard operating system protocols and returns responses and data to application **122b** exactly emulating operating system responses and data. Therefore the activity of wrapper application **150** is transparent to application **122b** and therefore the activity of application **122b** is according to operation standards and requires no modification due to the presence of wrapper application **150**.

In the example of Figure 1B, wrapper application **150** and application **122b** are both being executed by a single processor **121b**. Therefore in order to facilitate interception of commands, wrapper application wraps application **122b**. "Wrapping" application **122b** means that application **122b** does not run independently. Rather, when a user requests to start application **122b**, the request is passed through wrapper application **150**. Wrapper application **150** invokes application **122b** which runs "inside" of (is wrapped by) wrapper application **150** (that is to say all input and output to and from application **122b** is via wrapper application **150**).

At a later time, application **122b** issues a second file command, a read call **134b**. Read call **134b** accesses a target file **130b** and particularly at part **130b-ii**. Wrapper application **150**, in turn redirects read call **134b** and emulates reading data from target file **130b** by issuing a first read call **134c** that accesses target file **130b**. Read call **134c** is processed by file management system **124b**. File management system **124b** opens file **130b** for reading and reads **135c** data from part **130b-ii** of file **130b** and sends **137c** the read results data to wrapper application **150**.

Wrapper application **150**, then checks whether there exists a delta file **158** associated with target file **130b** and whether the update information in delta file **158** applies to the range of read call **134b**. In the example of Figure 1B, delta file **158** exists and the range of read call **134b** is contained in part **130b-ii** of file **130b**, and delta file **158** does contains update information for the range of read call **134b**. Therefore, in order to fulfill read call **134b** and return up to date read results data (the emulated read information) to application **122b** it is necessary to merge the update information pertaining to file command **152b** stored in delta file **158** with data from target file **130b**. Thus, read call **134b** constitutes a merge event that triggers merging of commands stored in delta file **158** with data stored in target file **130b**. To execute the merging, wrapper application **150** issues second read call **134d** that accesses delta file **158**. Read call **134d** is processed by file management system **124b**. File management system **124b** opens delta file **158** for reading and reads **135d** data from delta file **158** and sends **137d** the read results data to wrapper application **150**.

The read results data from reads **135c-d** are merged by the wrapper application **150** by applying the update information from read **135d** to the data from read **135c**, and the merged data are sent **137b** to running application **122b** emulating the return of read results data in response to the read request **134b**. Thus, wrapper application has emulated reading updated data from target file **130**. Application **122b** in unaware that it has not communicated directly with file management system **124b**.

At this point, the merged data from reads **135c-d** constitute an updated version of part **130b-ii** of target file **130b**. Because activity on data processing device **120b** is currently low in this example (there is plenty of free processing power so that updating target file **130** will not disturb any other process), wrapper application **150** updates target file **130b**. It will be understood that it is not necessary to update target file **130b** every time data are merged into a temporary file. To update target file **130b**, wrapper application **150** first instructs **152c** file system **124b** to write **139c** the merged data into delta file **158** (thus replacing the file command information previously stored in delta file **158**). Then wrapper application **150** instructs file system **124b** to update target file **130b** by replacing **193** part **130b-ii** with the merged data now stored in delta file **158**. Since both target file **130b** and delta file **158** already exist on the same storage device **126b**, then replacing **193** is accomplished merely by changing the address pointers to incorporate delta file **158** into target file **130b** in place of the part **130b-ii**. Particularly in the example of Figure 1B, the address of the pointer at the end of delta file **158** is set to point at the beginning of part **130b-iii** of file **130b** and then delta file **158** is closed. After wrapper application **150** verifies that delta file **130b** has been closed, target file **130b** is opened for writing and the pointer at the end of part **130b-i** of target file **130b** is set to point at the address of the beginning of delta file **158** and target file **130b** is closed. Finally the memory space of part **130b-ii** of delta file **130b** is freed for use by a future write command. Since delta file **158** has been entirely reallocated to target file **130b** therefore a memory pointer for the beginning of delta file **158** is removed from the directory of storage device **126b** effectively deleting delta file **158**. When there is a future write command, wrapper application **150** will need to create a new delta file.

In the example of Figure 1B, merging data copied from target file **130b** with commands stored in delta file **158** is triggered by read call **134b**. Merging is also triggered whenever there is a termination event that makes it necessary to update target file **130b**. Before updating target file **130b**, the update information stored in delta file **158** and data stored in target file **130b** are merged into a temporary file (as above, delta file **158** may serve as a temporary file). In this way the temporary file serves as a back up for target file **130b**, if a power failure occurs while updating target file **130b** thereby damaging target file **130b**, the data of target file **130b** can be recovered from the temporary file. Merging may also be triggered any time when there are available resources [memory space and processor time] after a time threshold has been exceeded since the last merging.

Many events may trigger the updating of a target file. Updating may be trigged periodically (for example, target file **130b** may be updated once every 15 minutes) or updating may be triggered by a termination event. Examples of terminations events include a closing down of application **122b** that has accessed the target file, or delta file **158** becoming too large (exceeding a size threshold), or a combination event (an example of a combination event is the combination of there being available resources (memory space and processor time) after a time threshold has been exceeded since the last updating).

It will be understood by one skilled in the art that delta file **158** may also consist of parts and a first part of delta file **158** may include a file command for part **130b-ii**, while the second part of delta file **158** contains a file command for part **130b-iii**. In such a case it is possible to merge part **130b-ii** with the first part of delta file **130b** and then update part **130b-ii** keeping part **130b-iii** of file **130b** in its original state, leaving delta file **158** containing only the second part. Similarly it will be understood that the first or last part of a file can be changed by changing a file directory address pointer or a stop bit. Other existing means of exchanging parts of files will be understood by one skilled in the art.

In the embodiment of Figure 1B, delta file **158** is stored on the same memory (portable memory device **126b**) as target file **130b**. It is to be understood that delta file **158** could be part of a temporary file residing in a fast volatile memory of data processing device **120b** or in a hard disk or in a non-volatile memory of data processing device **120b** or in another portable storage device or in a removable medium (for example a writable compact disk). Similarly, in the embodiment of Figure 1B, wrapper application **150** merges the data of reads **135c-d** into a space a volatile memory of computing device **120b** thus effectively redirecting read call **134b** to the space containing the merged data. It is understood that merged information could be stored on any memory device for example in a hard disk or in a non-volatile memory of data processing device **120b** or in another portable storage device or in a removable medium (for example a writable compact disk).

Figure 2 shows a data processing device **220** (such as a network of parallel processors), running an application **222** (such as the Microsoft Visual Studio®), a wrapper application **250**, and a file management system **224** (such as FAT32 or NTFS).

Application **222** issues a file command, a write call **236** operative to affect file **230** stored in a storage device **226**. Write call **236** is intercepted by wrapper application **250**. In the embodiment of Figure 2, wrapper application **250** is being executed by a processor **221b** while application **222** is being executed on a separate processor **221a**, a processor in the network of data processing device **220**. Wrapper application **250** redirects write call **236** by instructing **252** file management system **224** to save update information pertaining to write call **236** in delta file **258**. File management system **224** writes **239** to delta file **258** only the update information that is needed to update target file **230**. The update information pertaining to write call **236** is saved to delta file **258** while target file **230** remains unchanged. Wrapper application **250** reports back to running application **222** as if target file **230** has been updated, thus emulating writing to file **230**. In the example of Figure 2 delta file **258** is stored in a volatile memory of data processing device **220**.

Later upon detecting the occurrence of a "termination event" **288**, (in the example of Figure 2, the termination event **288** is the closing down of application **222**, which had issued write call **236** operative to affect target file **230**), wrapper application **250** updates target file **230**. Because delta file **258** is not stored on the same storage device **226** as file **230**, it is not possible to update target file **230** by copying data into delta file **258**, and applying the update information to the copied data in delta file **258** and changing pointers (as in the example of Figure 1B). In order to update target file **230** wrapper application **250** must first merge stored update information from delta file **258** with data from target file **230** into a temporary file **292** on storage device **226**. Thus, wrapper application **250** instructs **290** files system **224** to create **294** temporary file **292**, to copy **296** contents from target file **230** into temporary file **292** and to apply **298** the file commands (update information pertaining to write call **236**) stored in delta file **258** to temporary file **292**. Once merging ends successfully, wrapper application **250** instructs file system **224** to close temporary file **292** and to replace **293** target file **230** with temporary file **292**. Because both target file **230** and temporary file **292** already exist on the same storage device **226**, replacing **293** is accomplished merely by removing the pointer to the temporary file **292** from the from the file directory and changing the pointer (the stored address) of target file **230** to the address of temporary file **292** (thus effectively updating target file **230** and deleting the temporary file **292**).

In the example of Figure 2, because application **222** is not being executed by the same processor **221** as wrapper application **250,** wrapper application **250** cannot wrap (control all input and output of) application **222**. Therefore wrapper application **250** wraps file system **224** such that all calls to file system **224** pass through wrapper application **250**. Thus, wrapper application **250** effectively wraps storage device **226**.

It is understood that file **230** may be accessed by multiple applications. Thus, write commands from each application are intercepted by wrapper application **250** and redirected to delta file **258**. Similarly an attempt to read file **230** by any application will be intercepted and trigger a merge event. It will be understood to one familiar in the art that, unlike prior art single application file protection schemes (such as that used by Microsoft® Word) which must lock access to protected files, wrapper application **250** permits multiple applications simultaneous read-write access to target file **230.**

The possibility of locking file access and file access conflicts will also be understood by those familiar with the prior art. Particularly in the embodiment of Figure 1 where wrapper application **150** wraps only one or more particular applications (for example application **222**) but does not wrap file system **124b,** it is possible for a separate application (not wrapped by wrapper application **150**) to access file **130b** not via wrapper application **150**. In such cases, prior art solutions (such as locking file **130b**) exist (for example as described in Advanced Windows 3rd Edition by Jeffery Richter, Microsoft Press, Redmond Washington, 1997, and particularly pp 711-715).

It is understood that in an alternative embodiment data can be copied **296** from target file **230** to temporary file **292** as part of intercepting the first write call **236**. In such an embodiment, temporary file **292** would be a constantly updated version of target file **230** and updating target file **230** would consist only of closing temporary file **292** and moving the address pointer of target file **230** to the address of temporary file **292**.

In the example of Figure 2, processors **221a-b** are components of the multiprocessor network of data processing device **220**. It is understood by one skilled in the art that alternative processor configurations exist and are compatible with various embodiments of a system and method to protect a file. For example, processor **221b** could be an internal component of data storage device **226** or processor **221b** could be a component of dedicated file system server on a network.

Figure 3 shows a simplified flow chart of the reading process of the embodiment of

Figure 2. A read command from application **222** is intercepted **301** by wrapper application **250**. Wrapper application **250** first tests **302** if there exists a delta file containing update information for file **230** at which the read command is directed. If no delta file exists, then control is returned to file management system **224**, which processes the read command normally according to the prior art, reading **306** the requested range directly from target file **230** and returning **309** read results data to requesting application **222**.

If testing **302** returns a positive result (that there exists a delta file **258** containing update information for file **230** which is to be read), then wrapper application **250** further checks **304** if the update information of delta file **258** is operative to affect the range of the read command. If there is no update information for the requested range, then control is returned to file management system **224** which processes the read command normally according to the prior art by reading **306** the requested range directly from target file **230** and returning **309** data to requesting application **222**.

If testing **304** returns a positive results (delta file **258** contains update information for the range of data to be read), then wrapper application **250** merges **308** the data of the range to be read from the delta file and update information from the target file (by copying the range to be read from target file **230** to temporary file **292** and applying the update information from delta file **258** to the copied data in temporary file **292**), and returns **309** the merged data from the requested range to requesting application **222**.

Figure 4 shows a simplified flow chart of a merge process according to the embodiment of Figure 2. Wrapper application **250** detects **410** an occurrence of termination event **288** that indicates the need to start a merge process (before updating target file **230**). Particularly in the example of Figure 4, a user closes down application **222**, which has issued at least one command to modify target file **230** in the current session. When wrapper application **250** detects that the operating system of device **220** is closing down application **222** then wrapper application **250** commands **290** file system **224** to open **294** an empty temporary file **292** and to copy **296** content from target file **230** into temporary file **292**. Particularly in the example of Figure 4, the data to be copied to temporary file **292** are the data range that was to be accessed in write call **236**. Wrapper application **250** further commands file system **224** to apply **298** update information stored in delta file **258** to temporary file **292**. Particularly in the example of

Figure 4, delta file **258** contains update information pertinent to write call **236**. Once the update information stored in delta file **258** has been applied **298** to temporary file **292**, wrapper application **250** issues a command to close **411** temporary file **292** and a command to replace **293** part of target file **230** with temporary file **292** by changing the address in the pointer for the part of target file **230** to the address of temporary file **292**. Wrapper application **250** then proceeds to discard **413** the replaced part of target file **230** and delta file **258** by instructing file system **224** to report the memory space of the replaced part of target file **230** and delta file **258** as free space since they are no longer needed.

If a merge event is triggered while a separate application is writing to delta file **258**, then the merge process is suspended until the write operation is completed. Should there be a new write call to target file **230** after the completion of the merge process, then a new delta file will be opened **414**. Alternatively, a new delta file may automatically be opened **414** immediately after a merge process.

Alternatively or in addition to the closing down of application **222**, other examples occurrences that are interpreted as a merge event include (1) an issuing of a command to close target file **230**, (2) an occurrence of a condition dependent on a statistic related to a plurality of file commands for example when an application has been accessing data on storage device **226** on average once every minute over a predefined period of one hour and afterwards there passes a time interval thirty times the average access interval (30 times 1 minute equals 30 minutes) in which the application does not access storage device **226** then a merge process is automatically triggered, (3) an exceeding of a size of delta file **258** over a maximum size threshold (for example if the stored update information in delta file **258** exceed 100 kilobytes of information), (4) a passing of level of activity of an operating system under a minimum activity threshold (for instance when the memory and processor are less than 50% occupied over a 10 second period) or (5) an exceeding of a maximum time threshold since a prior merge event (for example wrapper application **250** may have a rule that whenever there passes for any file a 15 minute period since a previous merge event then a new merge process is begun. Another occurrence that may trigger a merge event is an issuing of a command to read target file **230** (as explained in the description of Figure 3, in order to read updated data it is necessary to merge data from target file **230** with the update information of delta file

258).

Figure 5 shows a simplified flowchart of a writing process. Application **222** issues a write call **236** to file system **224**. Wrapper application detects **540** write call **236** and checks **542** to determine if file **230** (to which the write command is directed) is a file to be protected. Specifically in the example of Figure 5 storage device **226** is a protected storage device. More particularly target file **230** is to be protected because target file **230** fulfills the following conditions. Target file **230** is stored on device **226**, which is a removable portable storage device that is subject to sudden unpredictable disruption due to premature removal. Therefore wrapper application **250** protects all permanent unprotected user files in storage device **226**. More specifically, by default all write commands to storage device **226** are intercepted and redirected unless the application issuing the write command is an excluded application (for example Microsoft® Word is an excluded application because Word has internal file protection and backup, also Adobe Acrobat® reader is excluded because Adobe Acrobat® reader does not store any modified user files) or unless the write command is operative to affect an excluded file type (for example a temporary file of type .tmp are excluded since data loss from a temporary files is seldom serious). When application **222** is an excluded application or the file to which the write command is directed is an excluded file type or the file at which the write command is directed is not in storage device **226** then file system **224** writes directly **549** to the file.

Alternatively, the conditions for intercepting and redirecting a file command may include one or more of the following conditions: the file command being issued by an included application (an included application is an application that is included on a list or group of applications whose file commands are to be intercepted by wrapper application **250**), the file command being issued by an application that is not an excluded application (an excluded application is an application belonging to a list or group of applications whose file commands are not to be intercepted), the file command being operative to affect a file that is not a temporary file, the file command being operative to affect an included file type (an included file type is a file having a type that is included in a list or group of files types to be protected), the file command being operative to affect a file that is not of an excluded file type (an excluded file type is a file having a type that is in a list or group of files types not to be protected) and the file command being operative to affect a file stored in a protected storage device. Contingent on the fulfillment of one or more of the above conditions, a wrapper applications will either intercept **501** and redirect **548** a write call, or wrapper application **250** will allow a file system to write directly **549** to a file as described above for a prior art file system of Figure 1A.

In the example of Figure 5, file **230** is a .txt file (which is not an excluded type) in storage device **226** (which is an included storage device) and application **222** is Microsoft Visual Studio® (which is not an excluded application). Therefore wrapper application intercepts **501** write call **236**. Wrapper application **250** then checks **544** whether or not a merge operation for file **230** is in process. If a merge operation is in progress, the write command process is suspended **546** until the merge operation is completed. When the merge operation is complete, the suspended write operation is resumed and the content of the write command is redirected **548** by saving to delta file **258** the update information pertaining to the write call **236**. If no merge operation is in progress, wrapper application **250** redirects **548** write call **236** and saves update information to delta file **258**. If a merge event is triggered while writing to delta file **258**, the merge event is suspended until the write operation is completed.

In sum, although various embodiments and preferred versions thereof have been described in considerable detail, other versions are possible. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred versions contained herein.

WHAT IS CLAIMED IS:

1. A system for storing a target file and protecting the target file from data damage comprising:
   a) a processor configured to retrieve and execute program code of a wrapper application, the program code including:
      i) code for intercepting at least one file command issued by another application, said at least one file command being operative to affect the target file, and said wrapper application being independent of said other application;
      ii) code for saving update information pertaining to said at least one file command, and
      iii) code for updating the target file according to said update information;
   b) a first memory space for storing the target file, and
   c) a second memory space for storing said update information.
2. The system of claim 1, wherein said first memory space resides in a nonvolatile memory of a data processing device.
3. The system of claim 2, wherein said second memory space resides in at least one memory selected from the list consisting of said nonvolatile memory of said data processing device, a separate nonvolatile memory of said data processing device, and a volatile memory of said data processing device,
4. The system of claim 1, wherein said first memory space resides in a nonvolatile memory of a portable data storage device.
5. The system of claim 4, wherein said second memory space resides in at least one memory selected from the list consisting of said nonvolatile memory of said portable data storage device, a memory of a data processing device, and a volatile memory of said portable data storage device.
6. The system of claim 1, wherein said update information includes only data pertaining to said at least one file command.
7. The system of claim 1, further comprising
   e) a third memory space for storing a temporary file, and

   wherein said wrapper application further includes
      iv) code for copying at least part of the target file into said temporary file;
      v) code for applying said update information to said temporary

WHAT IS CLAIMED IS:

1. A system for storing a target file and protecting the target file from data damage comprising:
   a) a processor configured to retrieve and execute program code of a wrapper application, the program code including:
      i) code for intercepting at least one file command issued by another application, said at least one file command being operative to affect the target file, and said wrapper application being independent of said other application;
      ii) code for saving update information pertaining to said at least one file command, and
      iii) code for updating the target file according to said update information;
   b) a first memory space for storing the target file, and
   c) a second memory space for storing said update information.
2. The system of claim 1, wherein said first memory space resides in a nonvolatile memory of a data processing device.
3. The system of claim 2, wherein said second memory space resides in at least one memory selected from the list consisting of said nonvolatile memory of said data processing device, a separate nonvolatile memory of said data processing device, and a volatile memory of said data processing device,
4. The system of claim 1, wherein said first memory space resides in a nonvolatile memory of a portable data storage device.
5. The system of claim 4, wherein said second memory space resides in at least one memory selected from the list consisting of said nonvolatile memory of said portable data storage device, a memory of a data processing device, and a volatile memory of said portable data storage device.
6. The system of claim 1, wherein said update information includes only data pertaining to said at least one file command.
7. The system of claim 1, further comprising
   e) a third memory space for storing a temporary file, and

   wherein said wrapper application further includes
      iv) code for copying at least part of the target file into said temporary file;
      v) code for applying said update information to said temporary

file, and

vi) code for replacing said at least part of the target file with said temporary file.

8. A method of employing a wrapper program to protect a target file from data damage, the method comprising:
   a) intercepting by the wrapper program of at least one file command issued by an application, said at least one file command operative to affect the target file, said intercepting step being transparent to said application;
   b) saving update information pertaining to said at least one file command without altering the target file, and
   c) updating the target file with said update information.
9. The method of claim 8, wherein said at least one file command includes every write command operative to affect the target file and issued by said application between a start of said saving and an end of said updating.
10. The method of claim 8, wherein said updating step includes:
    i) copying at least part of the target file into a temporary file;
    ii) applying said update information to said temporary file, and
    iii) replacing said at least part of the target file with at least part of said temporary file.
11. The method of claim 10, further comprising:
    d) deleting a delta file containing said update information subsequent to said applying step.
12. The method of claim 8, wherein said updating step is performed upon occurrence of at least one termination event selected from the group consisting of:
    i) an issuing of a command to close the target file,
    ii) a closing down of said application,
    iii) a closing down of an application that accessed the target file,
    iv) an occurrence of a condition dependent on a statistic related to a plurality of file commands,
    v) a passing of level of activity of an operating system under a minimum activity threshold,
    vi) an exceeding of a maximum time threshold since an issuing of said at least one file command, and

vii) an exceeding of a maximum time threshold since a previous merge event.

13. The method of claim 8, wherein said intercepting step and said saving step are contingent on at least one condition selected from the group consisting of said application being one of a plurality of included applications, said application being other than an excluded application, said at least one file command being operative to affect a file other than a temporary file, said at least one file command being operative to affect an included file type, said at least one file command being operative to affect a file other than an excluded file type and said at least one file command being operative to effect a file stored in an included storage device.

14. A system for reading data from a protected target file comprising:

a) a processor configured to retrieve and execute program code of a wrapper application, the program code including:

i) code for intercepting at least one file command issued by an application independent of said wrapper application, said at least one file command operative to access the protected target file;

ii) code for reading update information pertaining to said at least one file command, and

b) a first memory space for storing the protected target file, and

c) a second memory space for storing said update information.

15. The system of claim 14, wherein said wrapper application further includes:

iii) code for merging data from said protected target file with said update information into a temporary file.

16. A method of employing a wrapper program to read a protected target file comprising:

a) intercepting by the wrapper program of at least one file command issued by an application, said at least one file command being operative to access the protected target file, said intercepting step being transparent to said application;

b) reading update information pertaining to said at least one file command stored in a delta file, said delta file being separate from the protected target file, and

c) merging data from the target file with said update information,

d) returning a result of said merging as a response to said at least one file command.

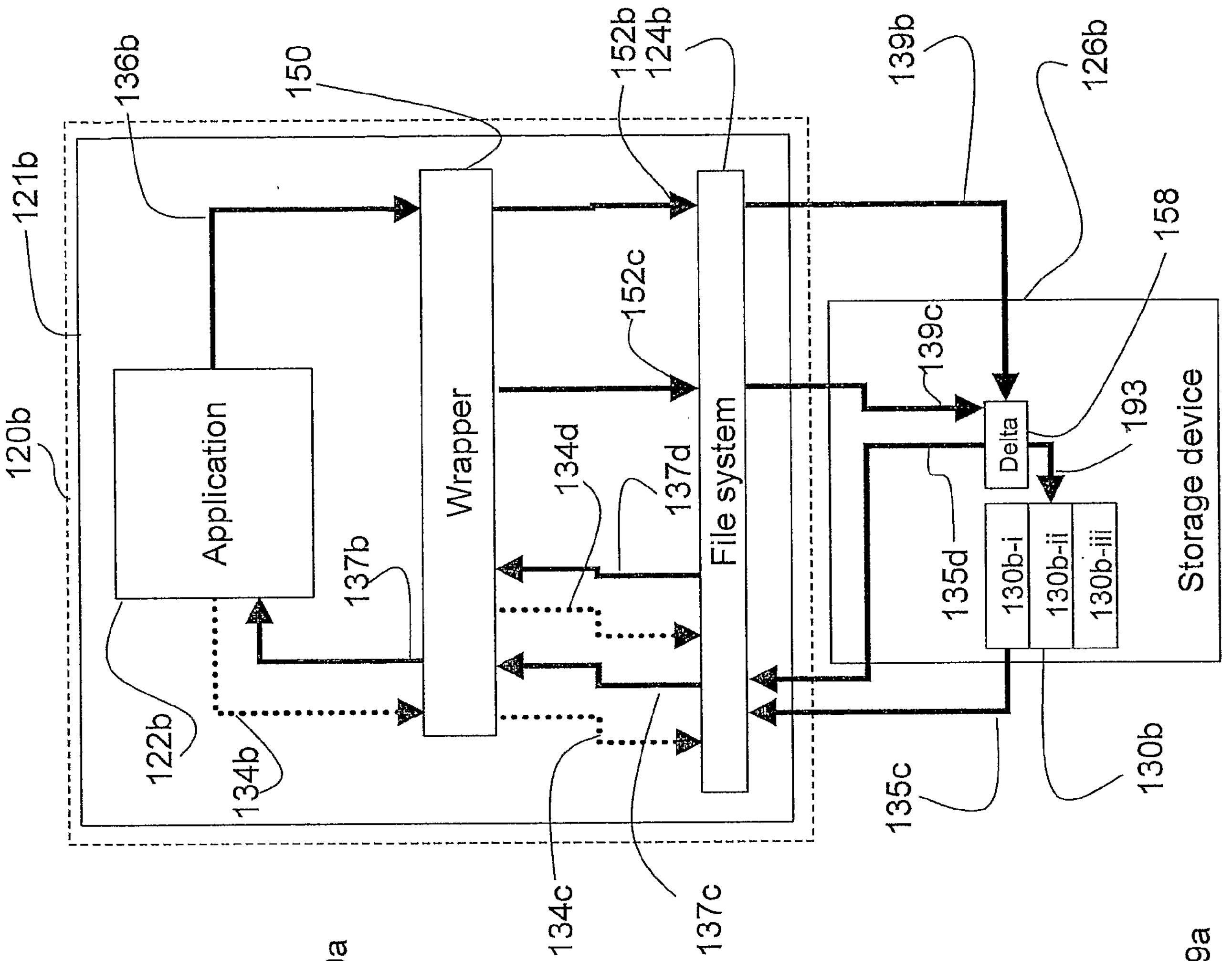


Figure 1B

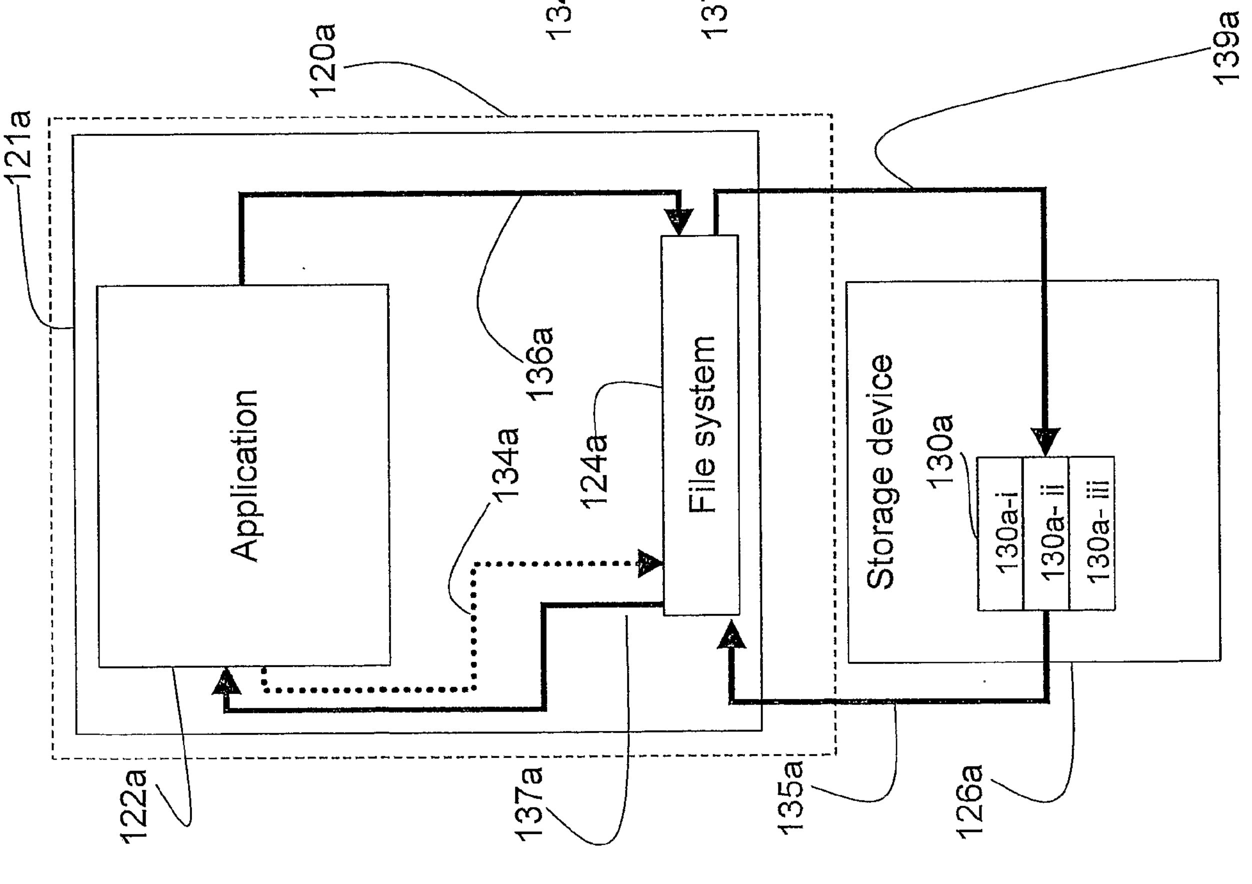
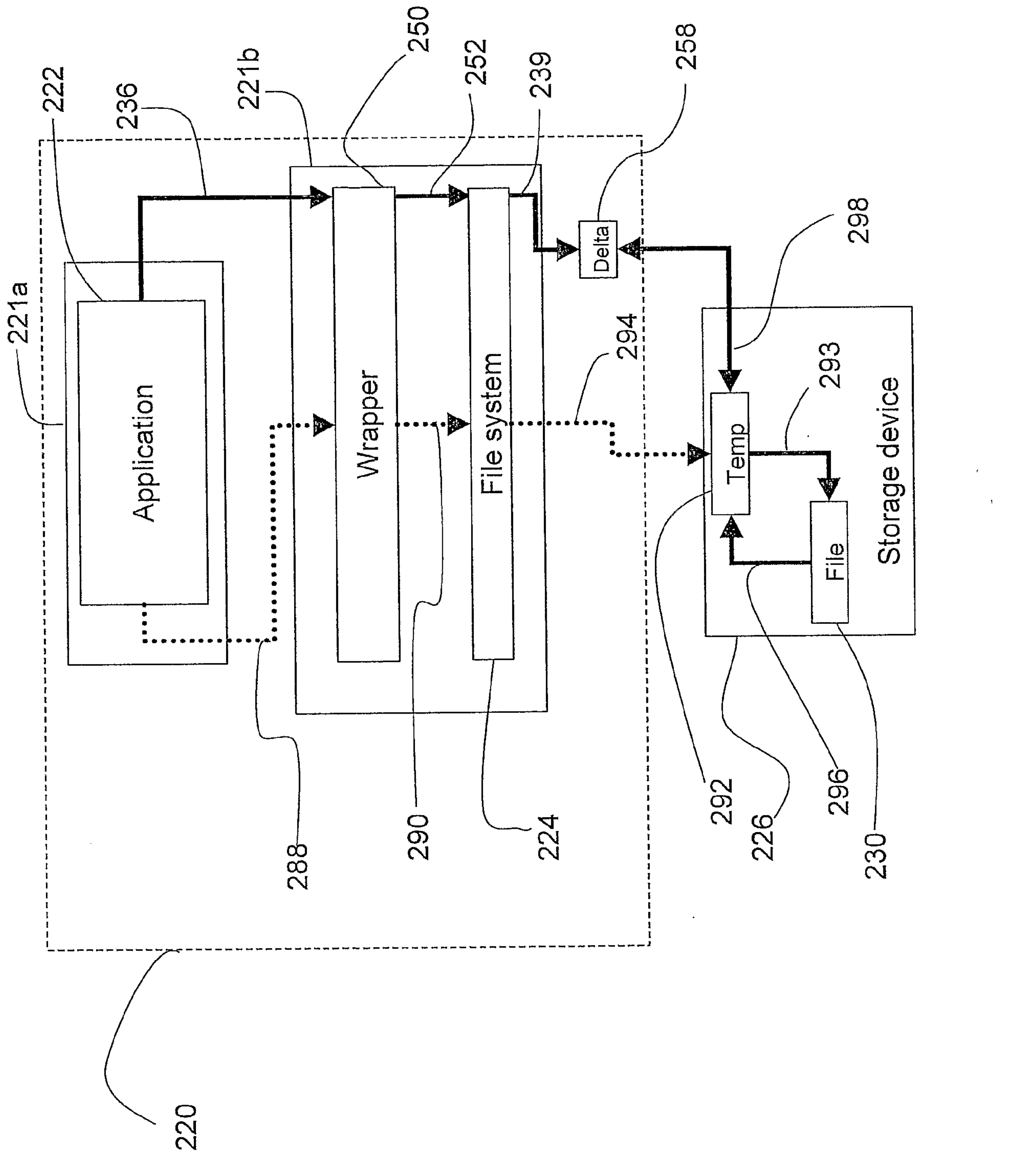


Figure 1A



220
221a
222
236
221b
250
252
239
258
Application
Wrapper
File system
Delta
298
294
293
Temp
File
Storage device
288
290
224
292
226
296
230

Figure 2

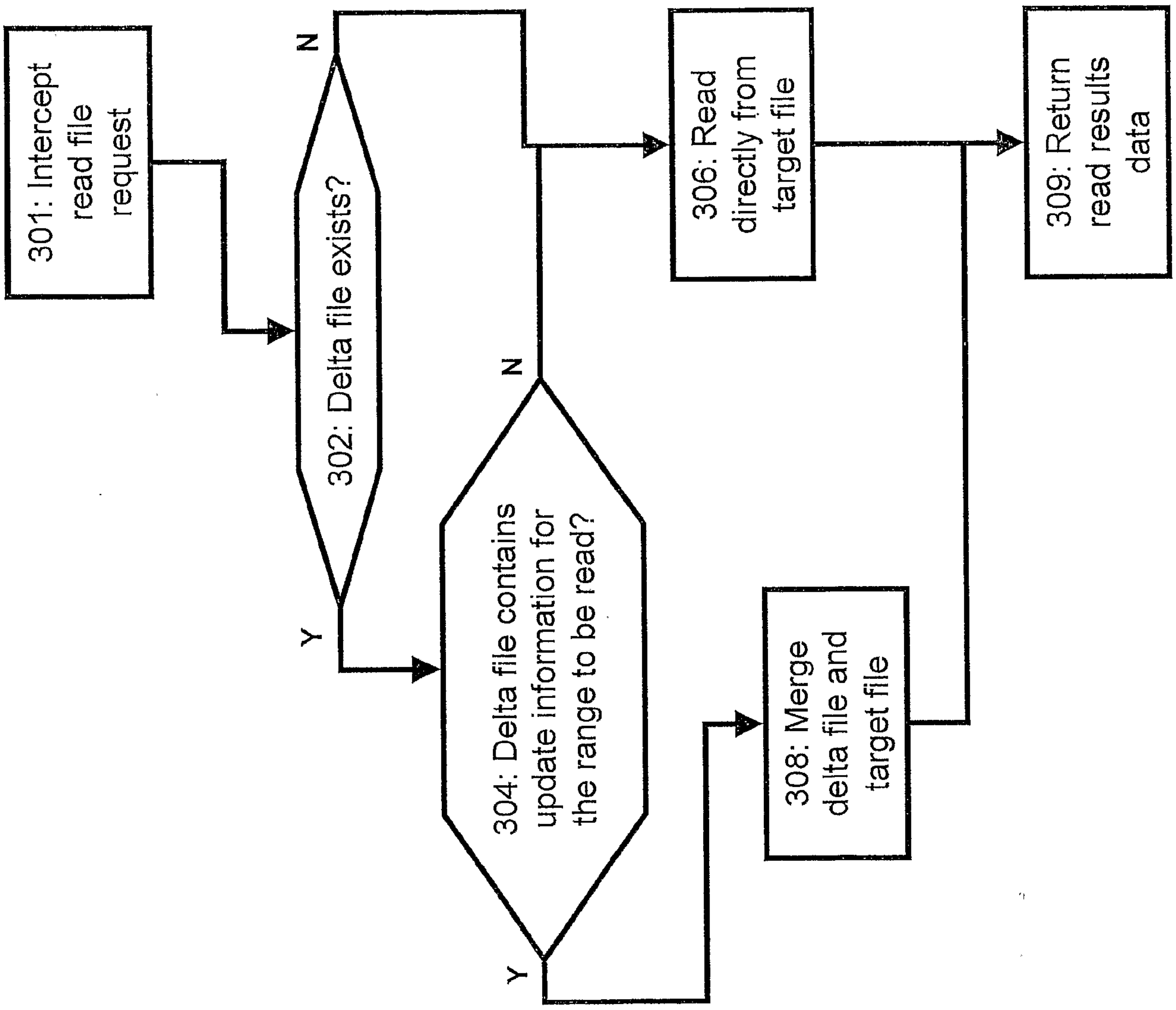

301: Intercept read file request
302: Delta file exists?
N
Y
304: Delta file contains update information for the range to be read?
N
Y
306: Read directly from target file
308: Merge delta file and target file
309: Return read results data

Figure 3

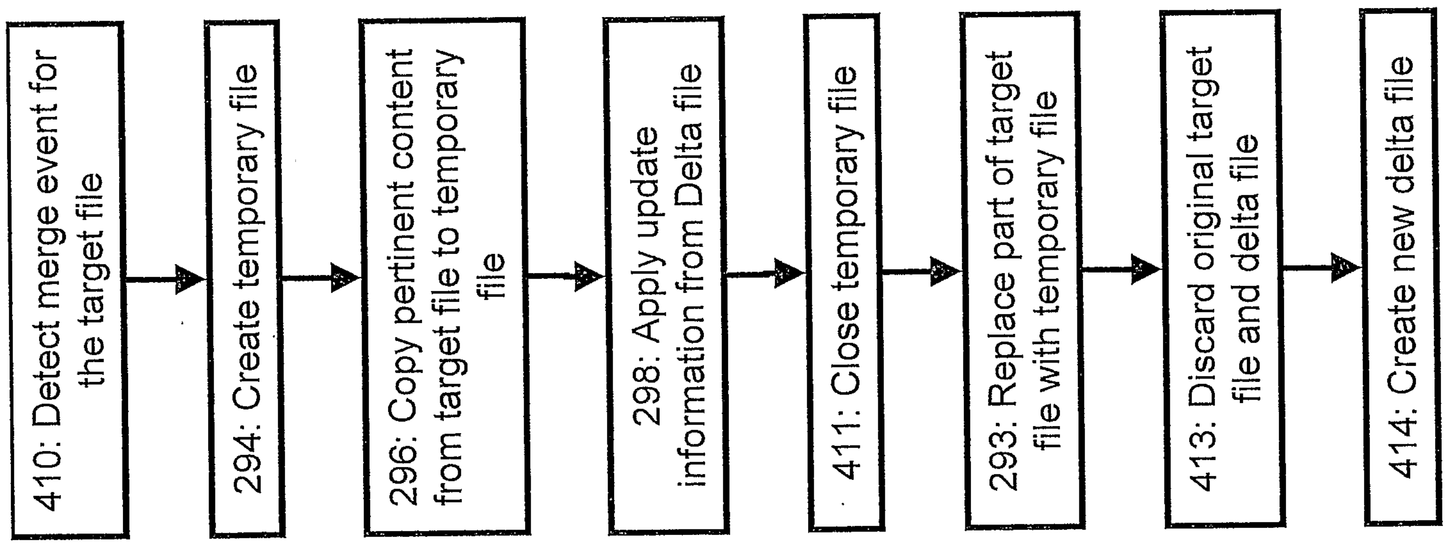

410: Detect merge event for the target file
294: Create temporary file
296: Copy pertinent content from target file to temporary file
298: Apply update information from Delta file
411: Close temporary file
293: Replace part of target file with temporary file
413: Discard original target file and delta file
414: Create new delta file

Figure 4

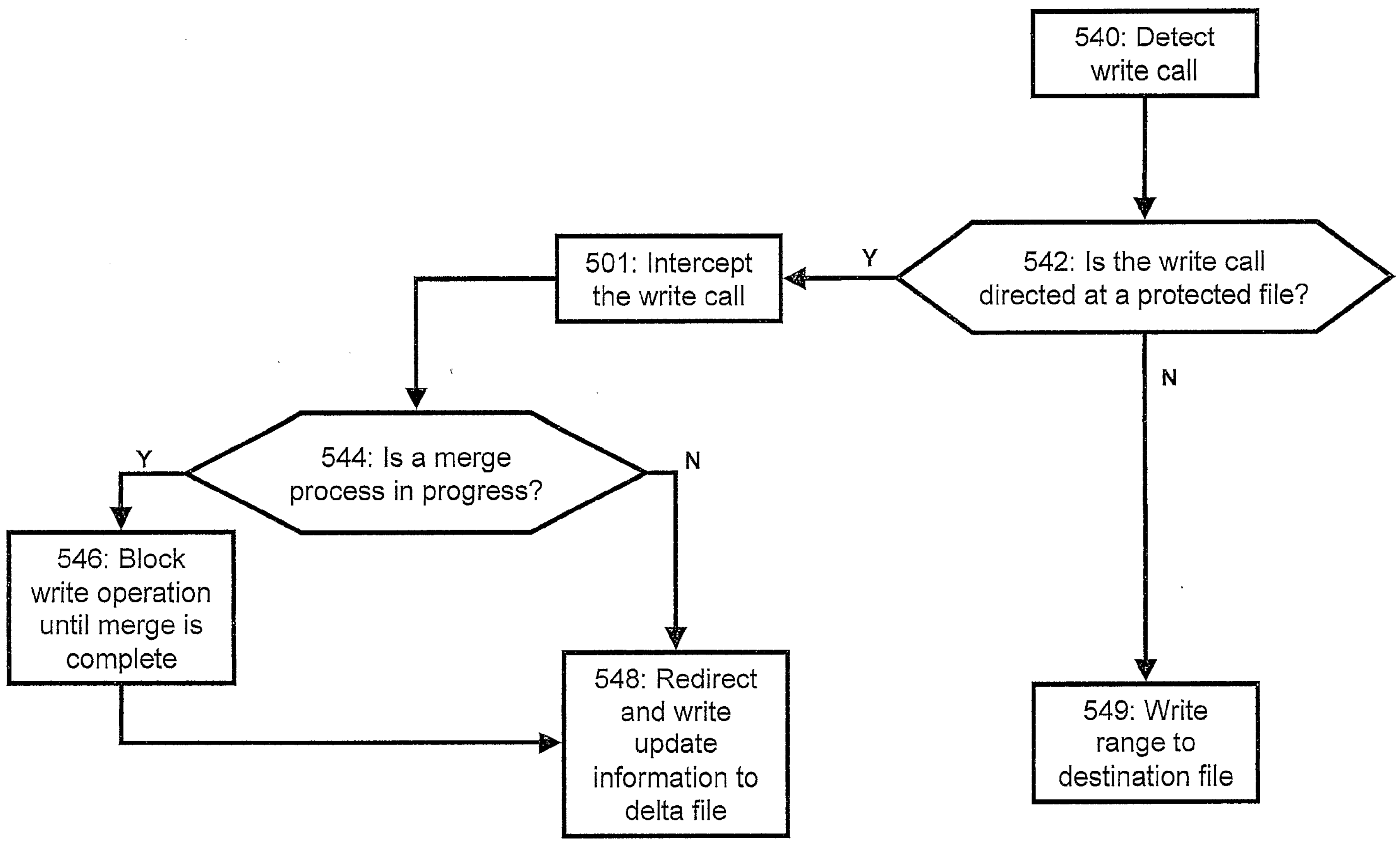

540: Detect write call
542: Is the write call directed at a protected file?
Y
N
501: Intercept the write call
549: Write range to destination file
544: Is a merge process in progress?
Y
N
546: Block write operation until merge is complete
548: Redirect and write update information to delta file

Figure 5