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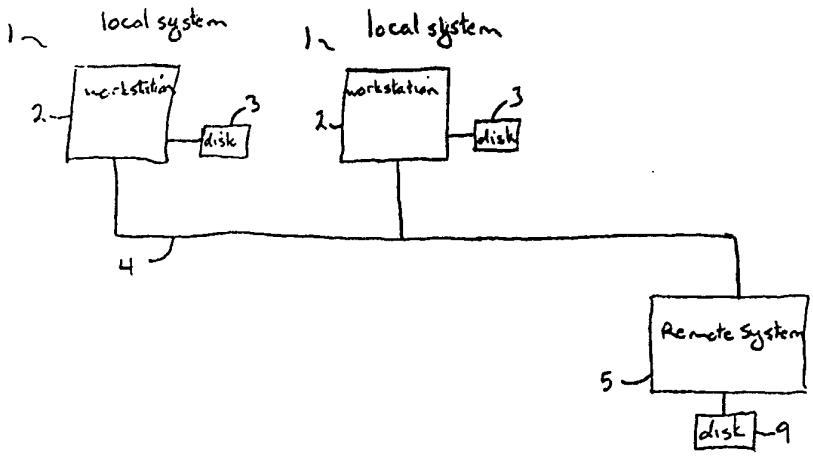
(54) Title: REAL-TIME DATA PROTECTION SYSTEM AND METHOD

(57) Abstract

A system and method for providing substantially concurrent mirroring of files across a network (7). A data file is selected for mirroring on a local computer system (1) and one or more remote computer systems (5) are designated to store a back-up copy of the selected data file. As changes to the selected data file occur, change information is captured by a mirroring driver (43), which is attached to the file system driver (44), and then forwarded from the local computer system (1) across the network (7) to the remote computer system (5) or systems. Each remote computer system (5) then updates the back-up copy of the data file.



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Real-Time Data Protection System and Method

FIELD OF THE INVENTION

The present invention relates to a system and method for providing real-time protection of data on computer systems connected to a network.

BACKGROUND OF THE INVENTION

There are several known methods for protecting computer data. One such method is to perform periodic batch back-ups of either an entire hard disk drive or selected files on a hard disk drive. Typically files may be selected based upon a file directory tree or other criteria, such as hard-coded filenames or filenames with wildcard characters. The data is typically written to a large capacity storage device, such as a tape-drive, connected directly to the computer system. Some batch back-up systems, however, such as the system described in U.S. Patent No. 5,133,065, permit data on computers connected to a computer network to be backed-up onto a centralized back-up device on the network. Where batch back-ups are used, it is usually recommended that disk-wide back-ups of data be performed infrequently, such as monthly, and that back-ups of new or modified files be performed frequently, such as daily.

A disadvantage of batch back-up systems is that the stored data is often out of date. Even nightly back-ups do not protect data accumulated since the last back-up. In certain businesses, such as banking and financial industries, the loss of even an hour of transactions can have serious repercussions. Another disadvantage of batch back-up systems is that typically the entire selected file is backed-up even if only a portion of the file has been modified. If the batch back-up system is operating over a network, valuable network resources are wasted transferring unchanged data.

Another known method for protecting data is to duplicate (or mirror) all data write operations occurring on a primary device onto one or more secondary (back-up) devices. In

systems utilizing this method, the data storage control unit for the primary device (such as a disk controller) is directly connected to either the secondary device itself or the control unit for the secondary device.

This type of data protection has been implemented using Redundant Array Inexpensive Direct access storage device (RAID) drives. A RAID drive is in essence a package of multiple, inexpensive disk drives. Mirroring has been accomplished by configuring the RAID drive controller to write the same data to two separate disks in the RAID drive.

Mirroring techniques are also used on fault tolerant computer systems. Fault tolerant computer systems have been available for mini-computers and mainframes for years, offering survival of any single point of failure in the system. These systems, however, often require expensive, redundant hardware, additional hardware for connectivity and frequently require specialized (often proprietary) operating systems.

One disadvantage of all known real-time mirroring systems is that none provides a granularity of mirroring smaller than a disk, partition or volume set. Also, none of the known real-time mirroring systems provides for mirroring across a local or wide area network.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and system for creating back-up copies of data files substantially concurrently with changes to those data files without using specialized hardware or operating systems.

It is a further object of the present invention to provide for back-ups at the level of individual files.

It is yet another object of the present invention to provide a back-up system that can be used with existing application programs that contain no data protection code without modification to the application programs.

The above and other objects are realized by the system and method of the present invention. Briefly, the present invention provides a data protection system that is not tied to specialized hardware or operating systems and that permits the user to specify a level of granularity of data protection down to individual files. In one preferred embodiment, a user initializes a configuration database that specifies the data files on a local system the user wishes to back-up (i.e., mirror) and the network location of a remote computer system to contain the back-up files. The system of the present invention provides a mirroring driver that is attached to the file system driver of the local computer system and intercepts operations on files (such as write operations, and delete, rename and change of attribute operations). By attaching the mirroring driver to the file system driver, the system of the present invention can mirror files accessed by existing application programs, having no data protection code, without modification to the application programs. The mirroring driver has a table with information read from the configuration database and determines if the operation is on a protected file. If it is, the mirroring driver stores information regarding the operation in a log file. A send process, which runs asynchronously from the mirroring driver, reads the log file and forwards the information regarding the operation from the local computer system across the network to the remote computer system containing the back-up file. The information is forwarded to the remote computer system using the standard methods provided by the networking software. A receive process on the remote computer system stores the information in its own log file and sends an acknowledgement to the source local computer system. A router process on the remote computer system then reads the remote computer system's log file and applies the operations to the back-up files.

In another preferred embodiment of the invention, the local system is itself a local area network having a plurality of workstations connected to a network server.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of the real-time data protection system of a preferred embodiment of the present invention.

Fig. 2 is a block diagram of the real-time data protection system of another preferred embodiment of the present invention.

Fig. 3 is a block diagram illustrating the components of the setup and initialization function.

Fig. 4a is a block diagram illustrating the components of the write intercept and store function.

Fig. 4b is a flow chart illustrating the operation of the write intercept and store function.

Fig. 5 is a block diagram illustrating the components of the write forward and confirm function.

Fig. 6 illustrates a preferred format of an entry in the Configuration Database.

Fig. 7 illustrates a preferred format of an entry in the Store and Forward Log.

Fig. 8 illustrates a preferred format of an entry in the Store and Forward Acknowledge Log.

Fig. 9 illustrates a preferred format of an entry in the router configuration database.

Fig. 10 illustrates a preferred format of an entry in an RT1 file.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates the basic hardware setup of a preferred embodiment of the present invention. One or more local computer systems 1, each comprising a workstation 2 directly connected to a disk drive 3 or other direct access storage device (DASD), are connected to a remote computer system 5 via a network 4. Network 4 may be a local or wide area network. On each local computer system 1, workstation 2 executes application programs that read and write data residing in data files on the disk drive 3. Workstation 2

also asynchronously executes data protection software. A first data protection program intercepts each write request, sends the write request to the disk drive controller and, for write requests to selected data files, locally stores a copy of the request. A second data protection program then forwards the request over network 4 to remote computer system 5. Remote computer system 5 contains duplicate (back-up) copies of the selected data files on disk 9. Upon receipt of a write request, a program on the remote computer system 5 stores the request in a request log and then sends a confirmation message to the local computer system 1 indicating that the request has been received by the remote computer system. The data protection software on the local computer system 1, in turn, marks the write request as complete upon receipt of the confirmation message from the remote computer system 5. Another program on the remote computer system later reads the request log and updates the remote copy of the data file. As is clear from this description, multiple local computer systems can communicate with one remote computer system.

All communications between the local and remote computer systems use standard network protocols and wiring. Preferably, a Microsoft® Windows NT™ based network is used that supports Microsoft's Remote Procedure Call (RPC) interface.

As shown in Fig. 2, local computer system 1 can be implemented as a local area network 7. Again, preferably a Microsoft® Windows NT™ based network is used that supports Microsoft's Remote Procedure Call (RPC) interface. In this case, workstations 2 execute application programs that read and write data in data files residing on disk drive 3 connected to network server 6. Network server 6 executes the data protection software, which intercepts and stores write requests. The data protection software also forwards write requests over local or wide area network 4 to remote computer system 5. As above, remote computer system 5 contains duplicate copies of selected files on disk 9. Upon receipt of

a write request, remote computer system 5 stores the request in a request log, sends a confirmation message to network server 6 and updates its copy of the designated data file. Network server 6, in turn, marks the write request as complete upon receipt of the confirmation message from remote computer system 5.

It is also possible to implement the present invention with multiple remote computer systems. In this case, the data protection software will direct write requests to a specific remote computer system or systems. It is thus possible to create multiple back-up copies of a single data file.

The software components of the preferred embodiment of the present invention can be divided into three basic functions: setup and initialization, write intercept and store, and write forward and confirm.

Setup and Initialization

Fig. 3 illustrates the setup and initialization function. A client configuration process 31 and server process 32 permit the user to add, modify or delete entries in configuration database 33. Configuration database 33 specifies the files to be mirrored. As shown in Fig. 6, an entry in configuration database 33 comprises a source file field 61, a destination site field 62, a destination file field 63, an attribute field 64 and a delete suffix field 65. Source file field 61 designates the file or files to be mirrored and preferably can be in any one of the following formats:

c:\a\x.doc	mirrors file c:\a\x.doc only
c:\a*.doc	mirrors all files ending with '*.doc' in directory c:\a (other wildcard characters can also be used)
c:\a\	mirrors all files in the c:\a subtree
c:\a*.doc\	mirrors all files ending with '*.doc' in the c:\a subtree

(Unless otherwise stated, references to filenames herein include the pathname.) Destination site field 62 designates

the network system name of the remote computer system that will contain the back-up file or files. The destination site can also be set to designate a DASD connected to the local computer system. Mirroring to multiple destination sites is accomplished by including a separate configuration entry for each destination site. Destination file field 63 designates the name of the back-up file or directory. If destination file field 63 designates a directory, which must be the case if multiple source files are specified, then the destination files are the files within the directory (or its subtree) with the same filenames as the source files. Attribute field 64 indicates whether attributes of the file (e.g., read-only or permissions) should be mirrored. Delete suffix field 65 designates a suffix that the back-up file or files should be renamed with, instead of deleted, when the mirrored file is deleted.

Referring back to Fig. 3, the user executes client configuration process 31 on local computer system 1 to specify changes to configuration database 33. If the user modifies or adds an entry to the configuration database, client configuration process 31 checks that the designated destination site and file are valid by sending a validation request to remote computer system 5. The request is processed by remote server process 35 on remote computer system 5, which verifies whether the destination file exists and can be written to and, if the destination file does not exist, whether it can be created. The result is then returned to client configuration process 31. If the remote server process 35 validates the request, client configuration process 31 then sends the entry to local server process 32. Local server process 32 first performs validity checks on the new or modified entry such as determining whether the designated source file or files are accessible. If the entry is valid, server process 32 writes the entry to configuration database 33. Server process 32 then notifies the send process 50 and mirroring driver 43, both described below, that an entry has been added or changed so that the send process 50 and

mirroring driver 43 can modify their tables to reflect the new information in its operations. (As used herein, tables refer to data stored in memory on the local and remote computer systems, as opposed to being stored, for example, on disk.)

Send process 50 performs two separate but related functions: sending configuration information to remote computer systems and sending mirrored file update information to remote computer systems. The latter function is discussed separately below.

When server process 32 notifies the send process of a change in the configuration, send process 50 increments the configuration version number 39. Configuration version number 39 identifies the latest version of the configuration database 33. Send process 50 sends configuration version number 39 and the entry to receive process 51 on the remote computer system. Receive process 51 adds the configuration version number to its remote configuration version number table 40. Each entry in remote configuration version number table 40 identifies the local machine and the latest version of the configuration database received from that machine. This information is used to ensure that the configuration information on the remote machine is in synch with the configuration information on the local machine.

Receive process 51 also writes the new entry to router configuration database 37. As shown in Fig. 9, an entry in the router configuration database 37 comprises a source file field 110, a source site field 111, a destination file or directory field 112, an attribute field 113 and a delete suffix field 114. All fields in the router configuration database are the same as the corresponding fields in configuration database 37, except for the source site field, which designates the local computer system from which the entry was received.

Router configuration database 37 contains all entries that designate the remote computer system as a destination site in all local computer system configuration databases. Router process 38, described in more detail below, reads the

router configuration database, at startup and when instructed to by receive process **51**, and updates the router configuration table, also described below.

If the user, through client configuration process **31**, indicates that an entry in configuration database **33** is to be deleted, server process **32** performs the deletion and also transmits the change to mirroring driver **43**. Mirroring driver **43**, in turn, flags the corresponding entry in its table as deleted.

Each time the local computer system is restarted, mirroring driver **43**, through server process **32**, and send process **50** read configuration database **33** and create a driver configuration table **49** and a send process configuration table **59**, respectively. Driver configuration table **49** contains for each source file listed in configuration database **33** the source file field and a cyclic redundancy check (CRC) based on the contents of the source file field. The CRC is used to optimize look-ups in driver configuration table **49**. The calculation of a CRC is well known in the art.

Send process configuration table **59** contains for each source file listed in configuration database **33** the contents of the source file field **61**, destination file field **63**, attribute field **64**, and delete suffix field **65**, and a list of the destination sites **62** designated in each configuration database entry having the same source file. The send process also generates a CRC based on the contents of the source file field.

Write Intercept and Store

The write intercept and store function is illustrated in Figs. 4a and 4b.

After the system has been started, file operations executed by application program **41** are passed to the input-output (I/O) manager **42** of the local computer system. I/O manager **42** passes the file operation to mirroring driver **43**, which in turn passes the file operation to file system driver **44**.

I/O manager 42 and file system driver 44 are standard operating system functions and are well known in the art. Mirroring driver 43 is attached to file system driver 44 using, for example, the IoAttachDevice call of Windows NT. In this way, the mirroring function can be implemented without requiring recompilation of application or operating system programs.

When a file open or create operation is passed to mirroring driver 43, mirroring driver 43 searches driver configuration table 49 to determine if the file is to be mirrored. Mirroring driver 43 first creates a CRC for the filename of the file being opened. If the configuration database entry is for a fixed filename, then the CRC is compared to the entry's CRC. If a match is found, then the name of the file being opened is compared to the source filename in the entry as a check in case two filenames have the same CRC. Once a fixed filename has been found, no other fixed filenames are searched for.

If the configuration database entry is for a wildcarded filename, a subtree, or a subtree including a wildcarded filename, the length of the filename of the file being opened is compared to the length of the fixed (or non-wildcarded) portion of the entry's source filename. If the length of the filename of the file being opened is less than the length of the fixed portion of the entry's filename, checking for this entry stops, since the entry could not possibly match the file to be opened. Otherwise, the fixed portion of the entry's source filename is compared to the initial portion of the filename. If a match occurs, the remaining portion of the filename is compared to the wildcarded portion, if any, of the entry's source filename.

If the filename of the file being opened matches any entries in driver configuration table 49, mirroring driver 43 stores the following information in an entry in a temporary list: the file object pointer (which uniquely identifies the file); a sublist having, for each matched driver configuration table entry, a pointer to the driver configuration table entry

and the part of the filename that matches the non-fixed portion, if any, of the driver configuration table entry; and the operation performed on the file (in this case, Open). Mirroring driver 43 then passes the open operation to file system driver 44. If the open operation completes successfully, the temporary list is added to Open File List 46; otherwise, the temporary list is deleted. Open File List 46 contains only one entry for each opened file and the entry points to all of the corresponding entries in driver configuration table 49.

When a write or truncate operation is passed to the mirroring driver 43, mirroring driver 43 checks the file object pointer to see if it is in Open File List 46. If it is, the mirroring driver 43 sets a flag indicating that mirroring is necessary upon successful completion of the I/O operation. Mirroring driver 43 then passes the I/O operation to file system driver 44. File system driver 44 attempts to perform the I/O operation and, if successful, returns a success code to mirroring driver 43.

If mirroring driver 43 receives a success code from file system driver 44 and the mirroring flag is set, mirroring driver 43 creates one or more entries in Store and Forward Log 47. As illustrated in Fig. 7, each entry in Store and Forward Log 47 comprises a source filename field 71, a CRC field 72, a command code field 73, a file offset field 74, a data size field 75, and a data field 76.

A Store and Forward Log entry is created for each configuration database entry corresponding to a file object in Open File List 46. Source filename field 71 contains the source filename specified in the driver configuration table entry followed by the part of the filename that matches the non-fixed portion (if any). CRC field 72 is set to be the same as the corresponding field in the driver configuration table entry. Command field 73 designates the action to be performed on the file (e.g., write data). File offset field 74 is set to the offset in the mirrored file at which data was written, and data size field 75 is set to the size of the data

written. Lastly, data field 76 contains a copy of the data that was written to the file. Preferably, a new Store and Forward Log is created when the current Store and Forward Log reaches a predetermined maximum file size.

After creating an entry in Store and Forward Log 47, mirroring driver 43 returns a success code to I/O Manager 42 which in turn passes it to Application Process 41.

File operations, such as delete, rename and change of attribute, are also processed by mirroring driver 43. For delete and change of attribute operations, the file is searched for in driver configuration table 49, as above. If a matching entry is found in driver configuration table 49 and the operation is successful on the local computer system, mirroring driver 43 creates an entry in Open File list 46, again as above. In this case, command field 74 is filled with delete or change of attribute information. For rename operations, mirroring driver 43 searches driver configuration table 49 for both the source and target name (where the rename operation renames the file from source name to target name). If the rename operation is successful on the local computer system and a matching entry is found in driver configuration table 49 for the source name, mirroring driver 43 creates an entry in Open File list 46 with command field 74 set to delete. Also, if the rename operation is successful and a matching entry is found in driver configuration table 49 for the target file name, mirroring driver 43 creates an entry in Open File list 46 with command field 74 set to copy. A command field set to copy indicates the file is to be copied to the remote computer system or systems.

When a file is closed, the mirroring driver 43 checks Open File List 46 for the file object being closed. If the file is found, mirroring driver 43 further checks whether the file has any pending delete, copy or attribute operations and, if so, writes the delete/copy/attribute information to Store and Forward Logs 47 with command field 74 set to the command in the Open File List entry and the offset, size and data

fields set to empty. Lastly, mirroring driver 43 removes the file's entry from the Open File List 46.

Write Forward and Confirm

The actual mirroring of data at the remote destination site (i.e., the write forward and confirm function) is illustrated in Fig. 5. Send process 50 executes on local computer system 1 and is responsible for forwarding write operations across network 4 to receive process 51 on remote computer systems 5.

Send process 50 executes in the background (i.e., asynchronously from other software on the local computer system) and periodically reads Store and Forward Logs 47. Preferably, send process 50 reads Store and Forward Logs 47 every tenth of a second or immediately if the previous read found new data to be forwarded.

At startup, send process 50 reads configuration database 33 and builds send process configuration table 59 in memory. Send process configuration table 59 basically contains essentially the same information as configuration database 33. Each entry contains the source file, destination site, destination file, attribute and delete suffix information of a corresponding entry in the configuration database 33. In addition, a CRC based on the source file is associated with each entry.

Send process 50 locates new I/O requests in the Store and Forward Logs 47 in two ways. At start-up and when a remote computer system becomes unblocked (described in more detail below), the send process 50 reads the Store and Forward Acknowledge (SFA) Log 54. SFA Log 54 contains an entry for each remote computer system that is to receive mirrored data. As shown in Fig. 8, each entry in SFA Log 54 comprises a remote computer system field 101 indicating the name of the remote computer system, a Store and Forward Log number field 102 indicating the Store and Forward Log containing the last entry that the remote computer system acknowledged receiving, and an offset field 103 indicating the offset of that last

entry in the designated Store and Forward Log sent to the remote computer system. With the information in SFA Log **54**, send process **50** can send all pending unacknowledged I/O requests to each unblocked remote computer system.

Alternatively, during normal operation, send process **50** maintains a pointer for each Store and Forward Log **47** to the last entry sent. Since send process **50** processes the entries in each Store and Forward Log **47** in first-in, first-out order, any entry in a Store and Forward Log after the last entry sent is new.

Once send process **50** locates a Store and Forward Log entry to send, send process **50** extracts the source filename and CRC information from the entry. Send process **50** then scans the entire send process configuration table **59** and locates the entry with the matching CRC, preferably using a binary tree search algorithm. If the command code in the Store and Forward Log entry is other than a copy command (which is discussed below), send process **50** then sends the source file, CRC, command code, offset, size and data fields of the Store and Forward Log entry, along with the current configuration version number **39**, to the destination site specified in the send process configuration table entry. As described above, configuration version number **39** designates the current version of the configuration database and is incremented each time the configuration database is updated. Configuration version number **39** is also incremented each time send process **50** is restarted.

On the remote computer system, receive process **51** receives the information sent by send process **50** and stores it in a pair of router log files (RT1, RT2) **56**. The receive process **51** first checks whether the configuration version number sent by send process **50** matches the configuration version number stored in remote configuration version number table **40**. If the version numbers do not match, the remote computer system's router configuration database **37** is not up-to-date. In this case, receive process **51** will return an error code instructs send process **50** to send the current

configuration information. Configuration version number table **40** is stored in memory and is cleared each time the remote computer system is restarted.

If the configuration version numbers match, an RT1 and RT2 entry are created. As shown in Fig. 10, each RT1 entry comprises the following fields: full source filename **210**, CRC **215**, command code **220**, back-up file offset **225**, size **230**, RT2 data offset **235**, source site ID **240** and flag **245**. The first five fields contain the information received from the local computer system. RT2 data offset information **235** indicates the offset of the data in the corresponding RT2 file. Source site ID **240** indicates the source machine that sent the request and flag **245** indicates whether execution of the operation designated in the entry is complete. The RT2 entry contains the raw data received from the local computer system.

If receive process **51** successfully writes the information to RT1 and RT2, receive process **51** sends an acknowledgement to the source machine. After receiving the acknowledgement, send process **50** marks the entry in Store and Forward Log **47** as complete and updates SFA Log **54**. When all entries in a Store and Forward Log are marked complete, the log can be closed. If the writes to RT1 and RT2 are unsuccessful, receive process **51** returns an error code. Preferably, a maximum size can be set for RT1 and RT2 files. If either router log file (RT1 or RT2) is at its maximum, receive process **51** will open a new pair of log files (e.g., RT1.00n and RT2.00n).

Router process **53** is responsible for applying the file update information to back-up files **55**. At startup, router process **53** reads Router Configuration database **37** into the router configuration table **58**.

Each RT1 file has a flag indicating whether it contains non-completed entries and the oldest RT1 file is processed first. Router process **53** reads an entry from the RT1 file and checks if the entry is marked as complete. If the entry is not complete, router process **53** checks blocked file log **57** (discussed below) to see if the entry is for a file which is

blocked. If the file is blocked, router process 53 skips the entry and reads the next entry.

If the file is not blocked, router process 53 searches Router Configuration database 37, using the CRC and source filename information, to determine which back-up file the file operation should be applied to. Router process 53 then checks if the back-up file is open and, if not, opens it. Router process 53 also creates the file, as well as any necessary directories, if the file does not exist. If ten files are already open, the least recently used open file is closed before opening the current back-up file. Router process 53 then applies the file operation to the back-up file and marks the entry in the RT1 file as 'complete'. If all entries in the RT1 file are complete, then router process 53 sets the file flag to 'file complete' and opens the next pair of router log files.

Copy Processing and Synchronization

If an entry in the Store and Forward Log 47 has command field 73 set to copy, send process 50 copies the file indicated in source filename 71 to the destination site(s) indicated in the matching entry for source filename 71 in send process configuration table 59. The copying is accomplished by simulating data writes that recreate the mirrored file and having the mirroring system of the present invention, described above, automatically create and/or rewrite the back-up file. If source filename 71 specifies a directory subtree, then all files in the directory subtree are copied to the destination site(s).

A user can also initiate copying of files from the source machine to remote machines through a synchronize command. This is typically done after adding existing files to configuration database 33 or when mirrored files and back-up files need to be re-synchronized. As shown in Fig. 4a, server process 32 processes the synchronize command by placing entries in Store and Forward Log 47, indicating that the specified files or directories are to be copied. Send process

50 then copies the files to the remote computer system or systems, as described above.

Blocking

Referring again to Fig. 5, if write requests cannot be sent to a remote computer system, because, for example, the network is malfunctioning, send process 50 adds the site to blocked site list 91 and notifies users on the local computer system that mirroring to the remote site is not concurrently occurring. Users can then decide whether to continue working on data files having back-up files on the remote computer system. If a user continues to work, write requests will be stored in the Store and Forward Log and the back-up files will be updated when the communications link is re-established.

The unblock command checks whether a blocked site has become unblocked (i.e., whether communications can be re-established with the remote computer system). If communications can be re-established, the unblock command informs send process 50, which in turn closes the current Store and Forward Log 47, opens the oldest Store and Forward Log 47 having entries for the site is unblocked and marks the entry for the site in blocked site list 91 as unblocked. Send process 50 then continues with normal processing. The unblock command is preferably automatically executed periodically (e.g., every five minutes) and also manually executable by the user at any time.

Blocking also occurs on remote computer systems when router process 53 detects that it cannot write to a back-up file. Router process 53 adds the router configuration table entry and the name of the router log file containing the blocked operation to remote blocked file log 57. Again an unblock command is automatically executed periodically or can be manually executed by a user.

When a file is unblocked, router process 53 marks the router configuration entry for the file in blocked file log 57 as unblocked. Router process 53 then closes the current RT1

and RT2 log files and opens the pair that were open when the file was blocked.

In addition to the above-described software and data files, one of skill in the art will appreciate that it is generally useful to maintain error log files on the local and remote computer systems for storing errors occurring during the operation of the system.

Server and Remote Server Start-up

When server process **32** is executed on the local computer system, server process **32** starts mirroring driver **43**, if not already started, and identifies for mirroring driver **43** the current Store and Forward Log **47**. Server process **32** also starts send process **50** if mirroring is on. In addition, server process **32** sets up an interface (e.g., an RPC interface) for communicating with client configuration process **31**.

On each remote machine, remote server process **35** likewise starts and manages receive process **51** and router process **53**.

A single computer system can act as both a local computer system and a remote computer system simultaneously, in which case all the processes and functions described above will be present on the single computer system.

In this disclosure, there is shown and described only the preferred embodiments of the invention. It is to be understood that the invention is not limited to the particulars disclosed and extends to all equivalents included within the scope of the claims.

What is claimed is:

1. A data protection system comprising:
   a. a local computer system containing one or more data files, which are accessed by at least one application program having no data protection code;
   b. a remote computer system for storing back-up copies of at least one of the one or more data files, each of the back-up copies corresponding to one of the one or more data files; and
   c. a network connecting the local computer system and the remote computer system;
   d. wherein, change information representing an individual change to one of the one or more data files by the at least one application program is transmitted from the local computer system across the network to the remote computer system.

2. The system of claim 1 wherein the individual change is a write operation.

3. The system of claim 1 wherein the individual change is a file operation.

4. The system of claim 1 wherein the change information is transmitted across the network substantially concurrently with the time the individual change is made on the local computer system.

5. The system of claim 1 wherein the back-up copies are updated with the change information received from the local computer system.

6. The system of claim 1 wherein the local computer system further comprises a log file in which the change information is stored before being transmitted to the remote computer system.

7. The system of claim 6 further comprising:
   a. a file system driver on the local computer system that applies the individual change to one of the one or more data files; and
   b. a mirroring driver attached to the file system driver which captures the change information and stores the change information in the log file.

8. The system of claim 6 wherein the remote computer system transmits an acknowledgement message to the local computer system after receiving the change information.

9. The system of claim 1 wherein change information for only selected data files is transmitted to the remote computer system.

10. The system of claim 1 wherein the local computer system further comprises:
   a. one or more workstations;
   b. a network server; and
   c. a local area network connecting the workstations and the network server.

11. The system of claim 1 wherein the local computer system and remote computer system are the same system and wherein transmitting information between the local computer system and the remote computer system across the network is accomplished by using a network interface.

12. A method of protecting data comprising:
   a. intercepting an operation on a data file performed by an application program having no data protection code and executing on a local computer system;
   b. transmitting information regarding the operation from the local computer system across a network to a remote computer system; and

c. updating a back-up copy on the remote computer system corresponding to the data file based on the transmitted information.

13. The method of claim 12 wherein the operation on the data file is a write operation.

14. The method of claim 12 wherein the operation on the data file is a file operation.

15. The method of claim 12 wherein the step of transmitting occurs substantially concurrently with the operation on the data file.

16. The method of claim 12 further comprising the step of storing the information regarding the operation in a log file before transmitting the information to the remote computer system.

17. The method of claim 16 further comprising the step of transmitting an acknowledgement message from the remote computer system to the local computer system after the remote computer system receives the information regarding the operation.

Fig. 1

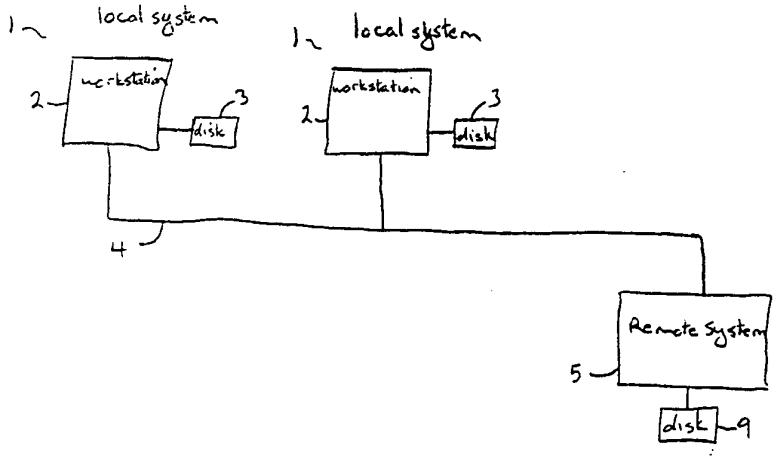

1
local system
2
workstation
3
disk
1
local system
2
workstation
3
disk
4
Remote System
5
disk
9

Fig 2

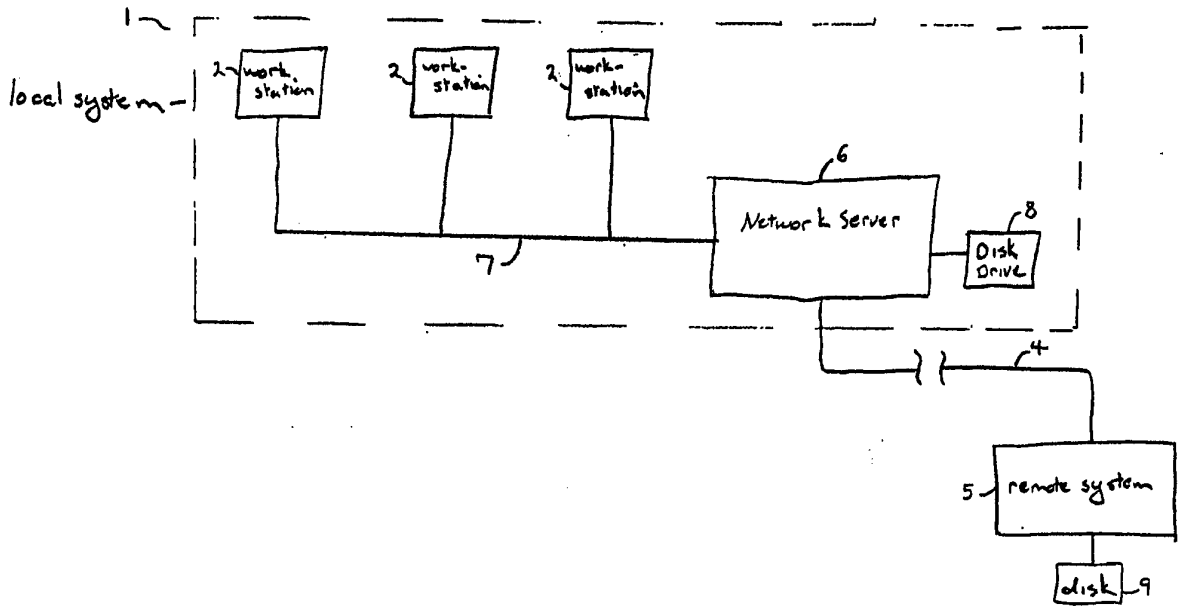

1
local system
2
work-station
2
work-station
2
work-station
6
Network Server
8
Disk Drive
7
4
5
remote system
disk
9

Fig 3

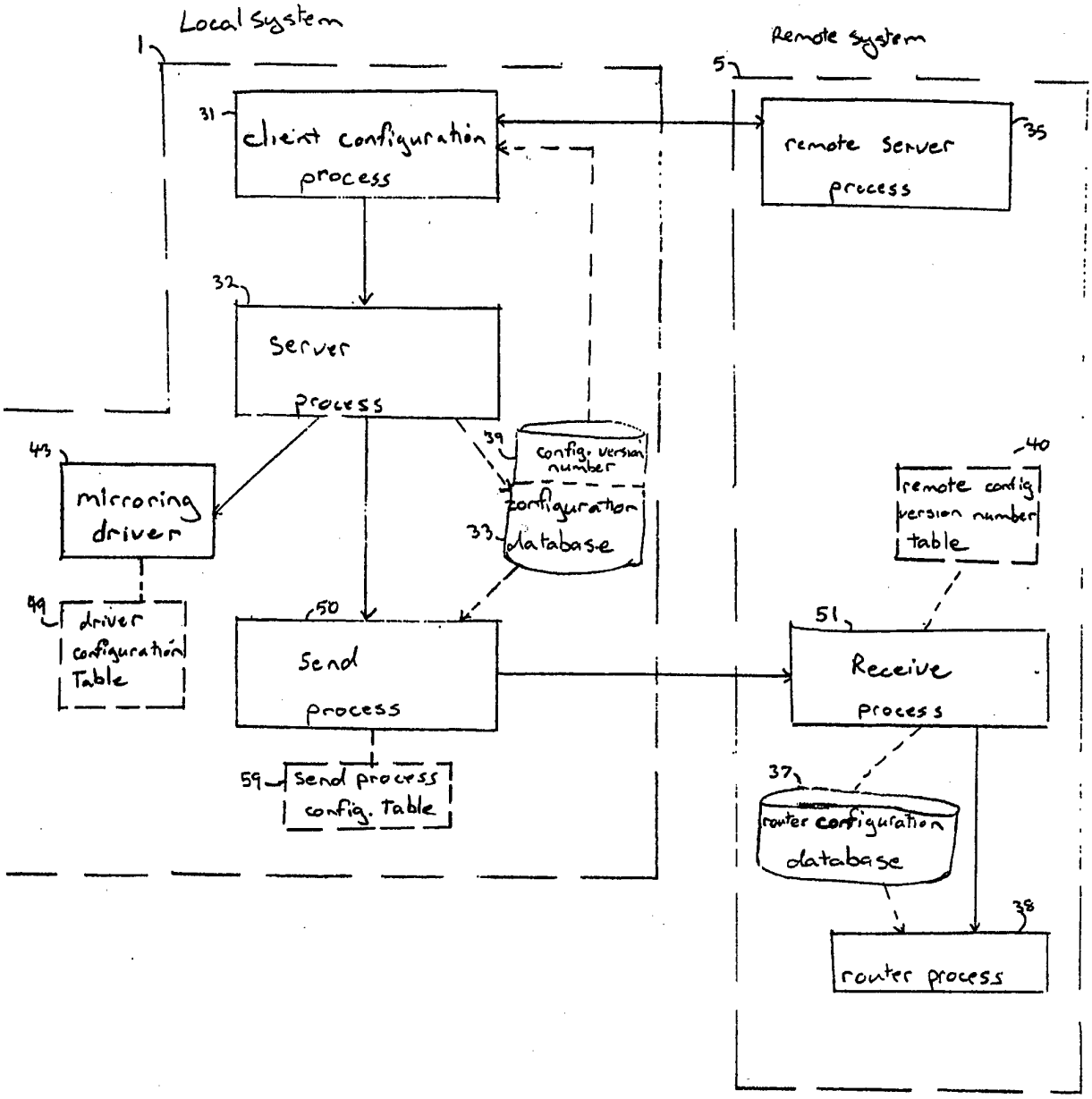

Local system
1
Remote system
5
31
client configuration process
35
remote server process
32
server process
39
config. version number
configuration database
33
43
mirroring driver
40
remote config version number table
99
driver configuration Table
50
51
Send process
Receive process
59
send process config. Table
37
router configuration database
38
router process

Fig. 4a

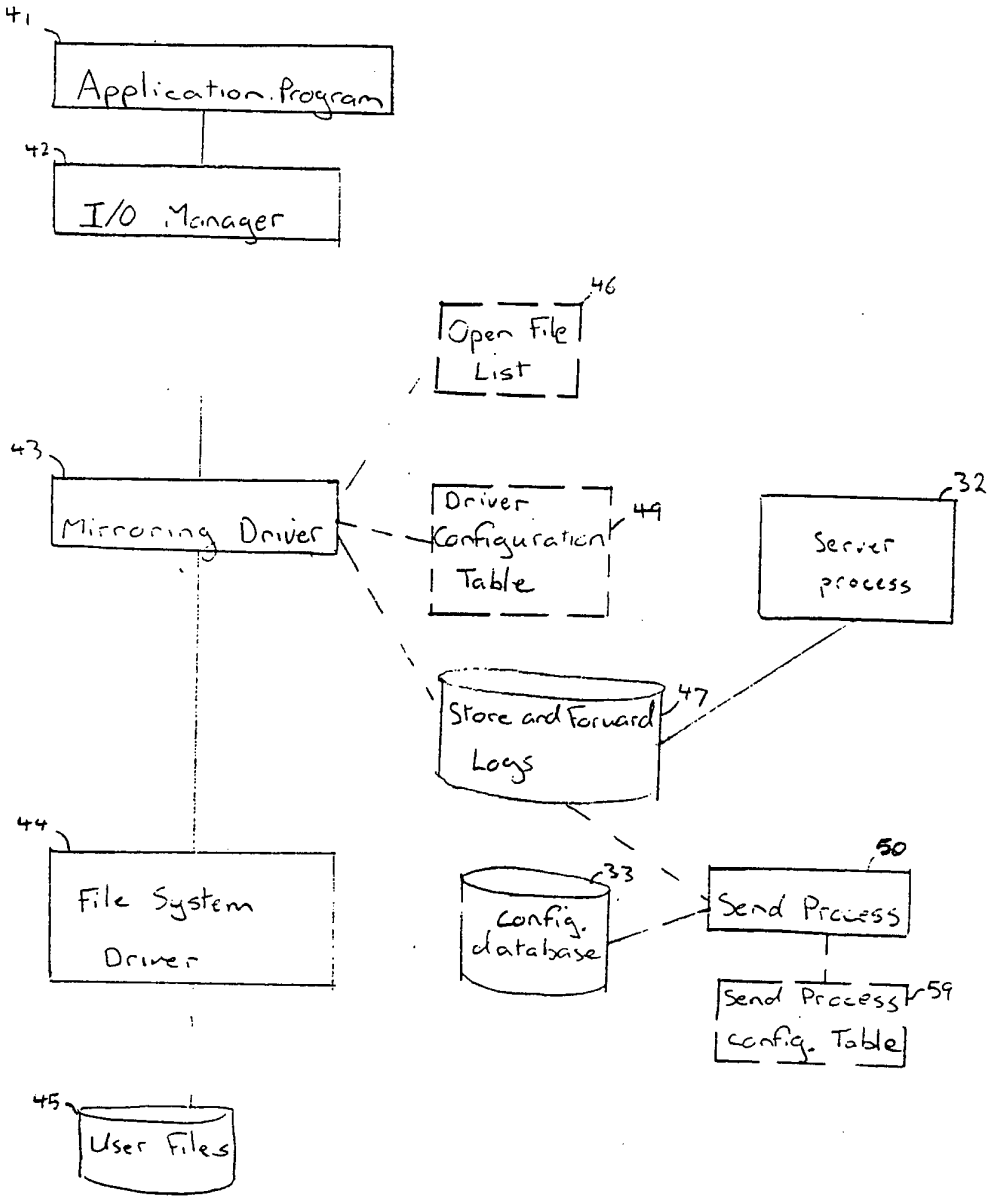
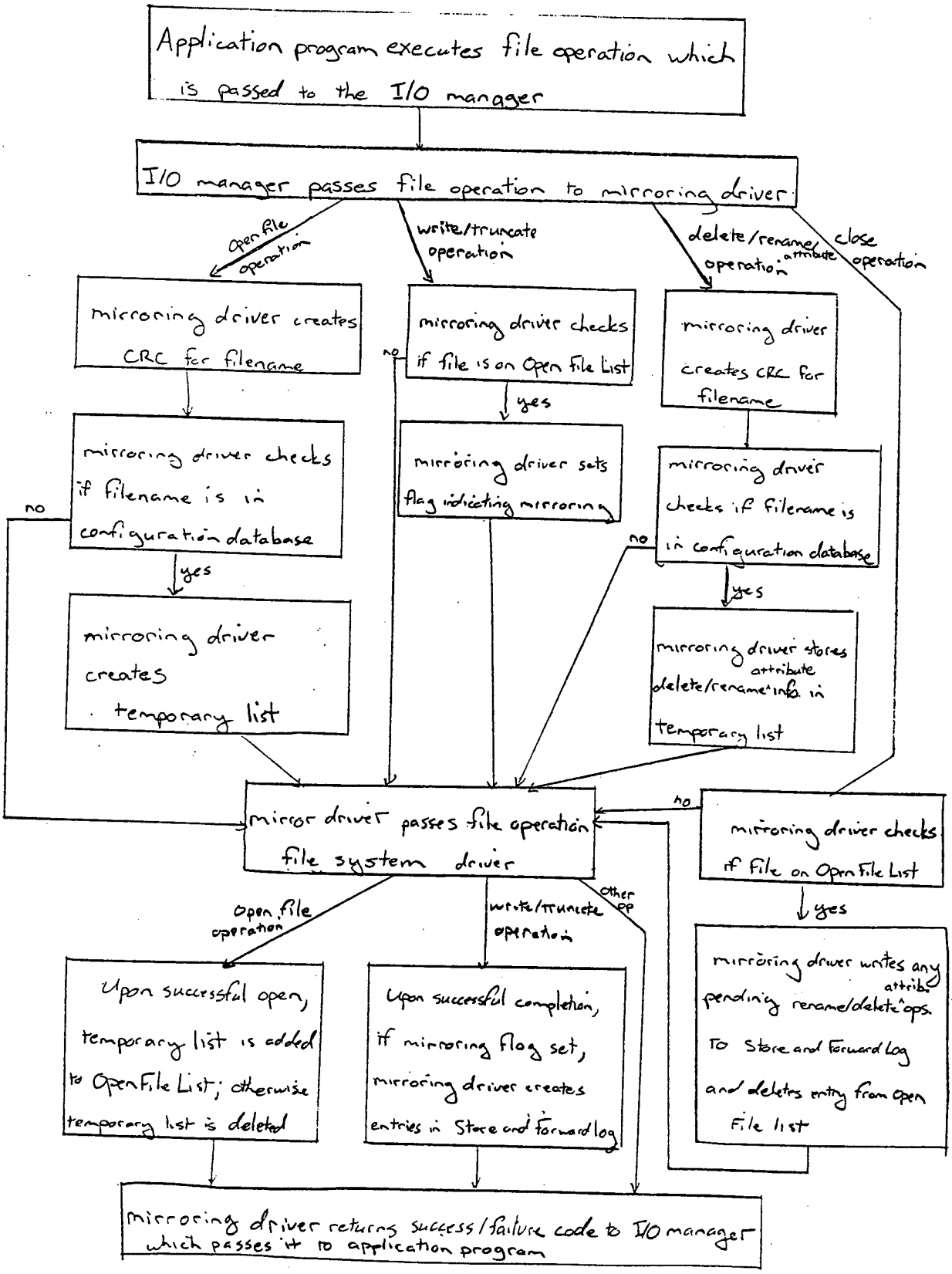

41
Application Program
42
I/O Manager
46
Open File List
43
Mirroring Driver
Driver Configuration Table
49
32
Server process
Store and Forward Logs
47
44
File System Driver
33
Config. database
50
Send Process
Send Process Config. Table
59
45
User Files

Fig. 4b.


Application program executes file operation which is passed to the I/O manager
I/O manager passes file operation to mirroring driver
open file operation
write/truncate operation
delete/rename/attribute operation
close operation
mirroring driver creates CRC for filename
mirroring driver checks if file is on Open File List
no
yes
mirroring driver creates CRC for filename
mirroring driver checks if filename is in configuration database
no
yes
mirroring driver sets flag indicating mirroring
mirroring driver checks if filename is in configuration database
no
yes
mirroring driver creates temporary list
mirroring driver stores attribute delete/rename info. in temporary list
mirror driver passes file operation file system driver
mirroring driver checks if File on Open File List
no
yes
open file operation
write/truncate operation
other IRP
Upon successful open, temporary list is added to Open File List; otherwise temporary list is deleted
Upon successful completion, if mirroring flag set, mirroring driver creates entries in Store and Forward log
mirroring driver writes any pending rename/delete attrib ops. To Store and Forward Log and deletes entry from Open File list
mirroring driver returns success/failure code to I/O manager which passes it to application program

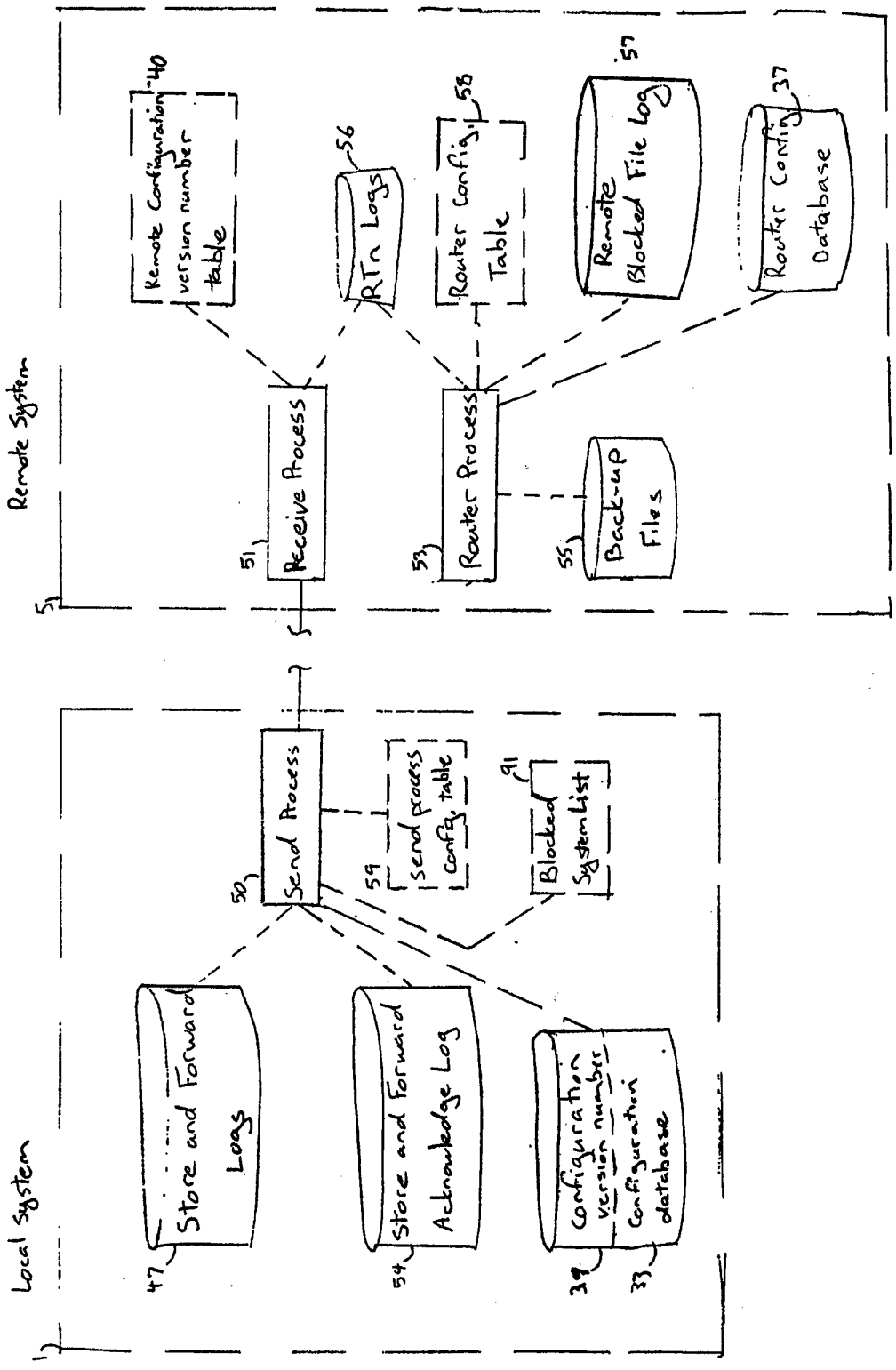

Remote System
5
Remote Configuration version number table
40
RTn Logs
56
Router Config Table
58
Remote Blocked File Log
57
Router Config Database
37
Receive Process
51
Router Process
53
Back-up Files
55
Send Process
50
Send process config. table
59
Blocked System List
91
Local System
1
Store and Forward Logs
47
Store and Forward Acknowledge Log
54
Configuration version numbers
39
Configuration database
33

Fig 5

Fig. 6

Configuration Database Entry Format:

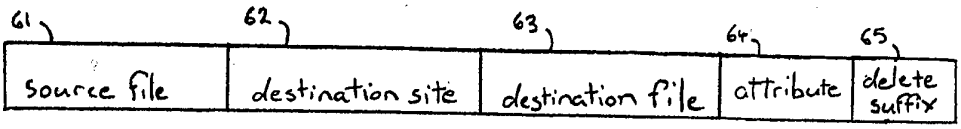


Fig. 7

Store and Forward Log Entry Format:

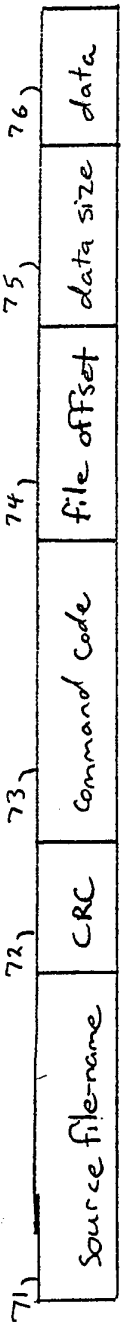


Fig. 8

Store and Forward Acknowledge Log Format:

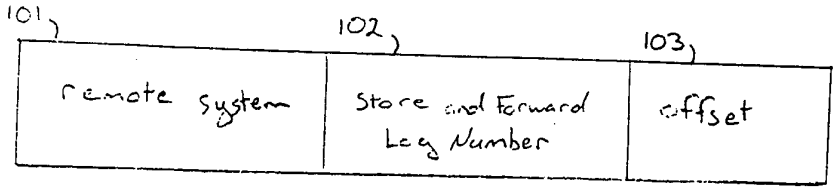


Fig. 9

Router Configuration Database Entry Format:

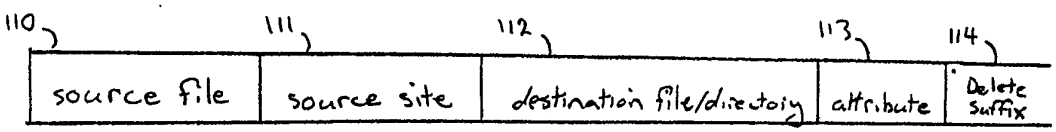
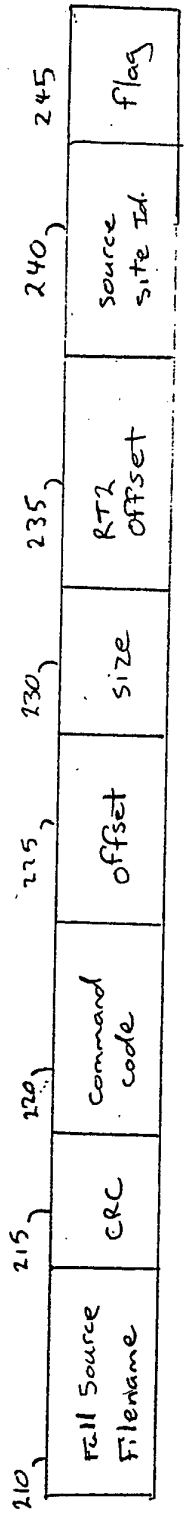


Fig. 10

RT1 Entry Format:



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/09843

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G01R 31/28; G06F 11/00
US CL : 395/182.04, 182.11
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 395/182.04, 182.11

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 4,959,768 (GERHART) 25 September 1990, see col. 1, line 57 to col. 2, line 2.	1, 4-5, 12, 15
Y	US, A, 5,133,065 (CHEFFETZ ET AL.) 21 July 1992, see col. 3, lines 17-27.	1-3, 5-14, 16-17
Y	US, A, 4,507,751 (GAWLICK ET AL.) 26 March 1985, see col. 2, lines 25-57.	1-3, 5-14, 16-17
A	US, A, 4,347,563 (PAREDES ET AL.) 31 August 1982, see entire document.	1-17
A	US, A, 4,351,023 (RICHER) 21 September 1982, see entire document.	1-17

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

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 30 JULY 1996	Date of mailing of the international search report 05 SEP 1996
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer for ROBERT W. BEAUSOLIEL Telephone No. (703) 305-9688

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/09843

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 4,710,870 (BLACKWELL ET AL.) 01 December 1987, see entire document.	1-17
A	US, A, 4,751,702 (BEIER ET AL.) 14 June 1988, see entire document.	1-17
A	US, A, 4,958,270 (MCLAUGHLIN ET AL.) 18 September 1990, see entire document.	1-17
A	US, A, 5,060,185 (NAITO ET AL.) 22 October 1991, see entire document.	1-17
A	US, A, 5,276,860 (FORTIER ET AL.) 04 January 1994, see entire document.	1-17
A,P	US, A, 5,454,099 (MYERS ET AL.) 26 September 1995, see entire document	1-17