PATENT
5760-00400
VRTS 0064

"EXPRESS MAIL" MAILING LABEL NUMBER EL849600979US
DATE OF DEPOSIT MARCH 28, 2002
I HEREBY CERTIFY THAT THIS PAPER OR FEE IS BEING DEPOSITED WITH THE UNITED STATES POSTAL SERVICE "EXPRESS MAIL POST OFFICE TO ADDRESSEE" SERVICE UNDER 37 C.F.R. §1.10 ON THE DATE INDICATED ABOVE AND IS ADDRESSED TO THE ASSISTANT COMMISSIONER FOR PATENTS, WASHINGTON, D.C. 20231

Paul Kennedy

Disaster Recovery and Backup Using Virtual Machines

By:

Hans F. van Rietschote

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is related to the field of computer systems and, more particularly, to backup and disaster recovery mechanisms in computer systems.

2. Description of the Related Art

Computer systems, and their components, are subject to various failures which may result in the loss of data. For example, a storage device used in or by the computer system may experience a failure (e.g. mechanical, electrical, magnetic, etc.) which may make any data stored on that storage device unreadable. Erroneous software or hardware operation may corrupt the data stored on a storage device, destroying the data stored on an otherwise properly functioning storage device. Any component in the storage chain between (and including) the storage device and the computer system may experience failure (e.g. the storage device, connectors (e.g. cables) between the storage device and other circuitry, the network between the storage device and the accessing computer system (in some cases), etc.).

To mitigate the risk of losing data, computer system users typically make backup copies of data stored on various storage devices. Typically, backup software is installed on a computer system and the backup may be scheduled to occur periodically and automatically. In many cases, an application or applications may be in use when the backup is to occur. The application may have one or more files open, preventing access by the backup software to such files.

Some backup software may include custom code for each application (referred to as a "backup agent"). The backup agent may attempt to communicate with the application or otherwise cause the application to commit its data to files so that the files can be backed up. Often, such backup agents make use of various undocumented features

of the applications to successfully backup files. As the corresponding applications change (e.g. new versions are released), the backup agents may also require change. Additionally, some files (such as the Windows registry) are always open and thus difficult to backup.

Disaster recovery configurations are used in some cases to provide additional protection against loss of data due to failures, not only in the computer systems themselves but in the surrounding environment (e.g. loss of electrical power, acts of nature, fire, etc.). In disaster recovery configurations, the state of data may periodically be checkpointed from a first computer system to a second computer system. In some cases, the second computer system may be physically located distant from the first computer system. If a problem occurs that causes the first computer system to go down, the data is safely stored on the second computer system. In some cases, applications previously running on the first computer system may be restarted on the second computer system to allow continued access to the preserved data. The disaster recovery software may experience similar issues as the backup software with regard to applications which are running when a checkpoint is attempted and the files that the applications may have open at the time of the checkpoint. Additionally, replicating all the state needed to restart the application on the second computer system (e.g. the operating system and its configuration settings, the application and its configuration settings, etc.) is complicated.

SUMMARY OF THE INVENTION

One or more computer systems, a carrier medium, and a method are provided for backing up virtual machines. The backup may occur, e.g., to a backup medium or to a disaster recovery site, in various embodiments. In one embodiment, an apparatus includes a computer system configured to execute at least a first virtual machine, wherein the computer system is configured to: (i) capture a state of the first virtual machine, the state corresponding to a point in time in the execution of the first virtual machine; and (ii)

copy at least a portion of the state to a destination separate from a storage device to which the first virtual machine is suspendable. A carrier medium may include instructions which, when executed, cause the above operation on the computer system. The method may comprise the above highlighted operations.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description makes reference to the accompanying drawings, which are now briefly described.

Fig. 1 is a block diagram of one embodiment of a computer system.

Fig. 2 is a flowchart illustrating operation of one embodiment of a backup program shown in Fig. 1.

Fig. 3 is a block diagram of one embodiment of a pair of computer systems, wherein one of the computer systems is a disaster recovery site for the other computer system.

Fig. 4 is a flowchart illustrating operation of one embodiment of a checkpoint program shown in Fig. 3

Fig. 5 is a flowchart illustrating operation of one embodiment of a recovery program shown in Fig. 3.

Fig. 6 is a block diagram of a second embodiment of a computer system.

Fig. 7 is a flowchart illustrating operation of a second embodiment of a backup program shown in Fig. 6.

Fig. 8 is a flowchart illustrating operation of a portion of one embodiment of a VM kernel.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION OF EMBODIMENTS

A computer system executes one or more virtual machines, each of which may include one or more applications. To create a backup, the computer system may capture a state of each virtual machine and backup the state. In one embodiment, the computer system may capture the state in cooperation with a virtual machine kernel which controls execution of the virtual machines, while the virtual machines continue to execute. The state may include the information in a virtual machine image created in response to a suspension of the virtual machine. In another embodiment, the computer system may capture the state by suspending each virtual machine to an image and backing up the image of the virtual machine. In this manner, the files used by the application are backed up, even if the application has the files open while the virtual machine is active in the computer system. Furthermore, updates to the files which are not yet committed (e.g. they are still in memory in the virtual machine) may be backed up as well. In some cases, only a portion of the state or image need be backed-up at a given time (e.g. non-persistent virtual disks may be backed-up by copying the COW files corresponding to those disks, if an initial copy of the disk file has been made).

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS
Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS
Sync your system to PACER to automate legal marketing.