HP One-Button Disaster Recovery

Technology overview

Technical Sales, Computer Peripherals Bristol

Edition 1, February 1999

Acknowledgments

Copyright Notice

Disclaimer

Printing History

Final electronic draft *17th February 1999*

Contents

Introduction

Hewlett-Packard One-Button Disaster Recovery (OBDR) represents a major improvement in the usability of disaster recovery systems. It should both encourage use of DR and reduce operator errors, giving increased dependability in practice.

The remainder of this white paper will look in detail at the technology involved in OBDR, discuss how to ensure it works in any given system, and consider where the technology may lead in the future.

Who this paper is aimed at

Technical specifiers

If you recommend backup solutions for HP NetServers, this paper provides useful information to assist you in specifying the appropriate backup solution for your customers

Reviewers and interested end-users

This paper gives an overview of the technologies that permit HP OBDR to work, and explains how these are applied to give real benefits in practice.

Why Hewlett-Packard OBDR is unique

Booting from a tape drive is not new. In fact, most dedicated UNIX™ workstations are able to do this, as can big transaction processing systems. Until now, however, it has been almost impossible for a standard PC to do so. There has never been BIOS support for sequential devices such as tape drives[i], and they can only function once drivers have been loaded later in the boot process. Consequently, the necessary minimal DR operating system cannot be loaded and the restoration process cannot start.

Hardware features

The *secret* of HP OBDR is simple: by a patented method the tape drive is switched into a special mode, emulating a CD-ROM drive with a bootable disk loaded. In this mode, it *can* be recognised by the system, which can boot using the tape drive alone. Once the restoration is under way, the drive is automatically switched back into 'normal' mode automatically by the software.

Mainstream software support

Achieving this breakthrough would be useless, without backup software able to take advantage of the drive's new capabilities. Hewlett-Packard has been working with the major backup software vendors to ensure that options for their *standard packages* can make OBDR tapes, and fully support OBDR tape drives. As a result, customers can take advantage of OBDR immediately, since the capability is available for backup packages that they *already use*[ii].

It is simple for software houses (if they wish) to release non-OBDR versions of the same software packages, which see OBDR tapes as normal backup tapes. This ensures full compatibility is maintained, so that OBDR tapes can be used to archive or migrate data, just like any other backup.

[ii] PC veterans going back to 1981 will recall that the original IBM PC BIOS supported program loading from audio Compact Cassettes, so, strictly speaking, tape support in the BIOS did exist, once. The author doesn t recommend using this feature to protect modern servers, since, even if the feature is still there, DOS 1.0 is not usually available for current systems!

[ii] In a few cases (when the customer is using an old version of backup software), it may be necessary to obtain a patch or update from the software vendor. Additionally, some software vendors supply disaster recovery modules separately from their main backup packages.

The need for OBDR

Comparing the alternatives

No one who has ever had to recover a server against the clock would question the value of single-button disaster recovery. Simply comparing the necessary tasks illustrates the value of the technique:

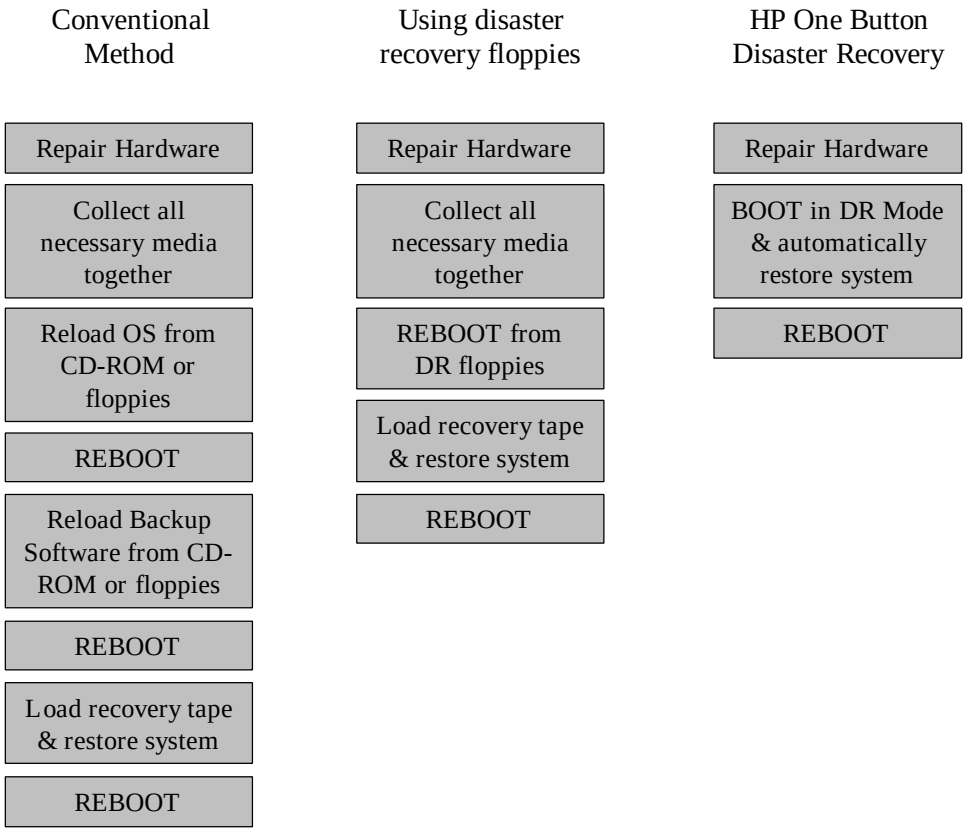


Figure 1: comparing the process steps for the various methods of disaster recovery.

In the **conventional method**, any problem at any time can delay the process or even prevent its completion. **Booting from special disaster-recovery floppy disks** or a CD-ROM (containing the *DR record* of the system configuration) does work, but the inherent vulnerability of floppy disks and CDs makes it potentially unreliable in practice.

In contrast **Hewlett-Packard One-Button Disaster Recovery** is almost entirely automatic. It only requires the backup tape to be available, and the process to be started manually. The DR record is stored on the tape itself: it cannot be separated from the backup set it relates to, and it is far less vulnerable to damage than other media.

How long will the recovery take?

Time required for completion is a significant weakness in conventional DR methods. It is not just the additional rebooting needed (depending on the exact method employed, each reboot can take up to twenty minutes), but the fact that floppy and CD-ROM technologies often have very slow transfer rates for loading vital data. In contrast, HP OBDR requires just a tape (and nothing else), and can restore *all* of the system as fast as the tape drive can stream – at speeds in excess of 2Mb/sec for Hewlett-Packard DDS-3 and DDS-4 drives

The hidden overhead of maintaining a DR system

Servers rarely keep the same configuration throughout their operating life. Even if a system is never upgraded (which is unlikely given the rapid growth of storage requirements) components still fail occasionally. Whenever this happens, items such as SCSI controller cards are often replaced with newer, better performing versions, requiring an updated driver to be installed at the same time. For a disaster recovery policy, this carries a hidden cost:

To work at all, any DR system must always up-to-date with the latest system configuration. If the SCSI card replacement described above is not reflected in the DR record, the system may be difficult to recover – it certainly won't start cleanly the first time after a failure.

So, for traditional DR, any change to the system makes it necessary to repeat the laborious procedure of creating the DR record, either on a set of floppy disks, or by 'burning' a new CD-ROM. This is usually a separate operation from the main backup process, and someone must sit by the computer 'feeding' it floppy disks as they are needed, or managing the CD-ROM creation process. Servers are often taken off-line during this process, since it is a maintenance activity, and, even then, the new DR disk set must join the tapes in the off-site data vault, else subsequent recovery of the server may have to happen without them!

Thus, with conventional DR, the downtime required to replace a failed component can easily double because of the requirement to update the DR record. Additionally, keeping the recovery disks up-to-date requires organisation and effort. In a large organisation, this can mean a significant additional system management cost

OBDR is simple and fast

There are clear advantages: updating the DR record takes place automatically and it is then only necessary to schedule a DR backup at the time the next normal backup should take place – for most software, this is the default setting, and in any case only involves selecting a single check-box. A fresh backup tape (or an old one to be overwritten) is the only other item needed. The OBDR backup will run completely unattended (just as any other backup). Downtime is minimal – the server can be brought back into normal use immediately, and no valuable engineer time is wasted "babysitting" the DR record creation process.

The Technology of HP OBDR

Activities in a generic disaster recovery

To recover a system, the following sequence of operations has to take place:

1. The system must boot in such a way that the DR process has control of it.
2. The basic structure of the system must be recreated, including all disk partitions and volumes, raid and mirroring.
3. The kernel of the usual operating system must be reloaded.
4. Essential device and service registry entries must be restored.
5. All data must be restored to its original locations.
6. A final reboot (into the usual operating system) returns the system to operational status.

The first stage is crucial: it enables the rest of process to happen automatically, and is described in detail below.

The boot process

From its earliest days, PC architecture has provided the ability to load and run different operating systems, so that users can tune the system to their requirements. Today, at least a dozen operating systems are in general use, ranging from the simplest, single-tasking DOS (Disk Operating System), to multi-processor, clustered, Network Operating Systems (NOS) from Novell, SCO and Microsoft.

The importance of the system BIOS

All these operating systems are the same during the initial stages of loading: they rely on the PC's ROM BIOS (Basic Input/Output System) to control the hardware. The BIOS is permanently stored in static Read-Only Memory (ROM) on the motherboard, and nowadays its purpose is to load operating system code from secondary storage (disk) into memory. Once this is achieved, it is usual for the operating system to manage the hardware directly, bypassing the built-in BIOS functions with its own, more efficient routines.

Booting for a disaster recovery

Disaster recovery systems make use of the same BIOS-controlled, boot process. A minimal "DR" operating system is loaded initially by the BIOS, with just enough functionality to complete stages two and three of the recovery process. It copies the essentials of the normal operating system from tape to their correct places on the system hard disks.

At this point the DR operating system is finished with, and a reboot will usually take place to load the normal operating system. The standard backup application code can then be run, to restore all non-essential parts of the operating system from tape, along with all user programs and data.

Addressing the requirements of the PC BIOS

The PC's ROM BIOS is vital to the disaster recovery system, since, no matter what storage medium is used for the main recovery, the DR operating system must be available for the BIOS to load at boot time. It is not possible to load a bootable image directly from a normal tape drive, since historically, the only device types directly supported by the BIOS for booting were floppy and hard disks. Recent improvements to BIOS and CD-ROM technology mean that, for most modern systems, CD-ROM is now also an alternative.

The actual boot device is usually decided in advance by the BIOS configuration chosen by the user (using whatever BIOS "setup" utility is provided by the manufacturer). By default, most systems look for bootable media in the floppy and CD-ROM drives first, before attempting to boot from the hard disk. This makes it easy to switch boot configurations and operating systems, by use of a selection of 'boot disks,' which could be floppy disk, CD-ROM or similar.

Providing support for bootable tape therefore requires that the drive should emulate either a floppy disk or a CD-ROM drive with a bootable disk loaded. This will "fool" the operating system into loading the correct boot image (in reality off tape), which can then start the main system restoration. The CD-ROM emulation is the most suitable for a number of reasons:

- CD-ROMs are much greater capacity than floppies, so the entire DR operating system can be contained in a single 'virtual' disk image, which reduces the complexity of implementation.
- CD-ROMs are available already with SCSI and ATAPI interfaces; floppy disks generally are not. This means that the necessary support for bootable CD-ROMs is already present in the BIOSes of most SCSI controllers.

Not surprisingly, the Hewlett-Packard OBDR firmware emulates a bootable CD-ROM drive.

How the tape drive behaves

The most significant development in the Hewlett-Packard OBDR system is new firmware for the tape drive, enabling it to emulate a bootable CD-ROM drive. This functionality is triggered by switching off the unit, and holding in the front panel 'eject' button whilst restoring the power (if the drive is mounted inside the server it is necessary to power-cycle the computer).

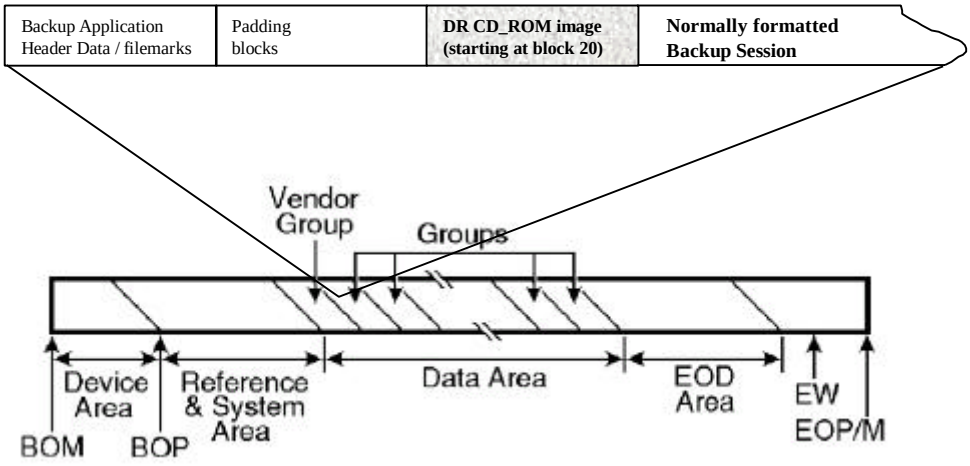


Figure 2: logical and physical (lower) layout of an HP One-Button Disaster Recovery tape

Once switched into DR mode, the DDS tape drive waits, and checks any tape it receives for a disaster recovery header. Any non-DR tape is ejected, but once it detects a DR tape, it proceeds to read the special DR CD-ROM image block, and the computer boots from this code.

Hewlett-Packard has implemented sophisticated caching algorithms in the tape drive's firmware, to make optimum use of the drive's buffer RAM. Additionally, the specification requires the software to write the boot image as near sequentially as possible on the tape. Taken together, these two features ensure that booting off tape is fast and that access times are well within the typical timeouts built into system BIOSes.

The format for this CD-ROM image block on tape is defined by the industry-standard *El Torito* bootable CD-ROM specification, and the exact contents are determined by the backup software that wrote the tape. The code loaded into memory is just sufficient to boot the computer and permit the operating system and restore software to be loaded, so that a full restoration can take place.

At some point in the process the drive is switched out of OBDR mode, back to normal operation. The drive switches in response to a SCSI bus RESET, but it will not do this automatically until sufficient blocks have been read sequentially from the tape in DR mode. This is so that the tape drive remains ready in DR mode even if the system is rebooted during the initial stages of the recovery.

Switching from DR mode to normal operation can also occur under software control or it can be forced by power-cycling the drive manually. In effect, the DR CD-ROM image on tape completely obsoletes the set of floppy disks or custom-written CD-ROM required by earlier technologies, and eliminates the need for the operating system CD-ROM during the recovery.

Compatibility

Backwards compatibility

The DR image is stored in the data area of the tape, which is laid out under software control. The Hewlett-Packard OBDR specification requires that all OBDR tapes must be readable by non-OBDR (basic) tape drives, so that restoration of files from any drive is possible. This also allows HP OBDR technology to be progressively rolled-out across an enterprise, giving improved protection whilst still maintaining the ability to perform remote restoration of data across the network.

	Software		**Drive hardware**	
	OBDR	Basic	OBDR	Basic
Read OBDR tapes	yes	yes*	yes	yes, but not for DR purposes
Write OBDR tapes	yes	no, but could append to OBDR tapes	yes	no, but could append to OBDR tapes

Table 1: Required read/write compatibility for OBDR tapes.

**Basic software will not be able to read the DR image off tape, but will read the normal backup set data.*

Tapes conforming to the HP OBDR specification can be used for normal file-by-file restore, using basic drives and software, without prejudicing the OBDR capability.

Future compatibility

The Hewlett-Packard OBDR specification has been carefully designed to support both present and future PC technologies, by making use of established standards as much as possible. For example, both the BIOS Boot Specification and support for the El Torito format are required components of the Microsoft PC99 definition. The PC99 standard comes into effect from Fall '99, so that almost all commercially built PC systems after that date will automatically be able to support OBDR, without even requiring manual changes to their BIOS settings.

Wider connectivity and standardization

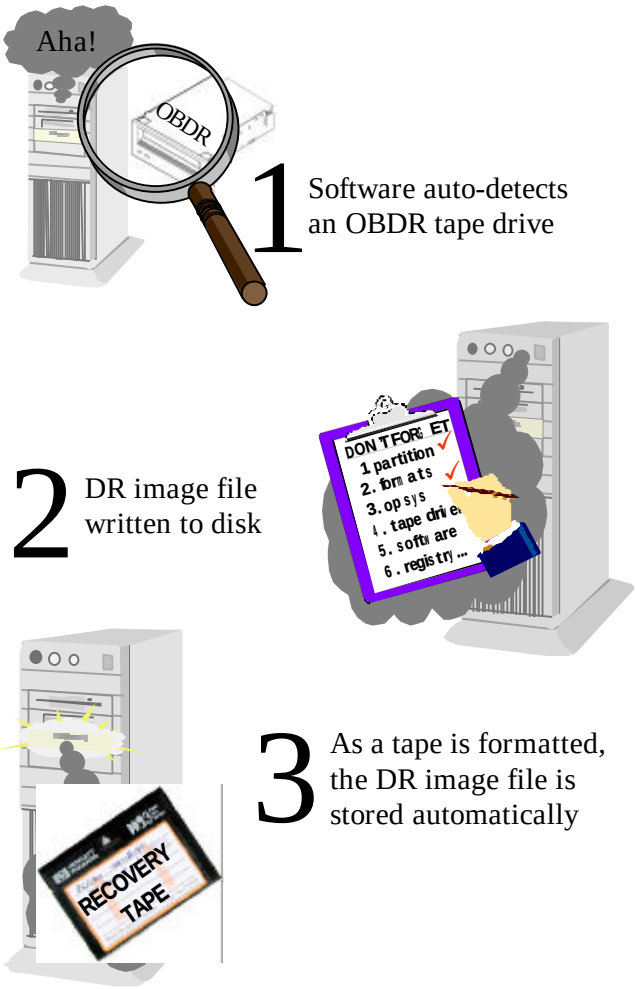
Hewlett-Packard SureStore One-Button Disaster Recovery represents a major step forward in data protection, and, as a consequence, Hewlett-Packard is keen to see it implemented as widely as possible. The full specification for HP OBDR has already been published to software vendors, and the technique of switching the tape drive between CD-ROM emulation and normal behaviour has patents pending globally. Hewlett-Packard intends to licence the technology to interested parties, so that it will eventually become an internationally recognised standard.

The software element of HP OBDR

The disaster recovery CD ROM image

Much of Hewlett-Packard's new OBDR specification is devoted to creating a framework which software vendors can then use to implement their own OBDR system, adapting their existing code as little as possible. Firmware in the HP DAT drive emulates a bootable CD-ROM drive, but the "virtual CD" (which the system will boot from) is written by the backup software.

The "virtual CD" varies with backup software implementations (for example, three of the major software vendors each have slightly different approaches), but it always contains one essential component: bootable code to restart the computer and reload the original operating system, including drivers for the main peripherals.



Interacting with the tape drive

Automatic detection of an OBDR drive (1) takes place either when the software is installed, or when the drive is first connected. The user is presented with a splash screen by the software, indicating a successful detection and explaining details of HP OBDR.

Detection also triggers the software to create the special DR CD-ROM image file on disk (2). It is copied to tape (3) at the first opportunity, either when a new tape is formatted, or when an existing tape is re-used from the beginning.

At this point the tape is theoretically just about usable for disaster recovery (although the full system could not be restored without an earlier backup). The tape becomes fully DR-capable once the first normal backup completes. Until then, it does not contain all the data files.

As the system configuration changes, the vital disaster recovery information is kept up-to-date on the hard disk, and automatically written to tape whenever a new tape is used (or an old one overwritten). This is required by the HP OBDR specification.

Figure 3: Auto-detection of the tape drive and the software's subsequent tasks.

User interaction with OBDR Software

In the middle of a stressful disaster recovery, the last thing a system administrator wants to have to do is learn a new piece of software. It is obviously helpful if the disaster recovery features of software are consistent between products from different manufacturers. To this end, Hewlett-Packard has produced a Software Developers' Kit for One-Button Disaster Recovery, to facilitate the inclusion of this functionality in existing disaster recovery products. It includes sample dialogs, relevant source code and methods for software-hardware interactions. The intention is not just to accelerate the adoption of this technology, but to ensure that a broadly similar OBDR user interface is presented by all of the major software vendors.

So how would a typical interaction look? This section uses illustrations from Stac Software's Replica for NT Server product, which is supplied with HP SureStore Tape products. Other software may differ in screens and detail, however the fundamentals should be quite similar.

Auto-detection of the tape drive

The HP OBDR specification requires that the tape drive is auto-detected, either when the software is installed, or (if the software is already on the system) the first time that the software communicates with a newly-added tape drive.

Figure 4: An OBDR drive has been auto-detected during software installation. The user is informed by the installation utility.

Once the OBDR drive has been identified, the user can be informed. This is an opportunity to explain what steps are necessary to test the OBDR functionality and make the first, real, OBDR-protected backup.

Selection of the OBDR option for Backup

HP OBDR backups are intended to happen automatically, so there are almost no operational controls for users to alter. In most software implementations, a single check box determines whether or not an OBDR tape is made at the next scheduled backup.

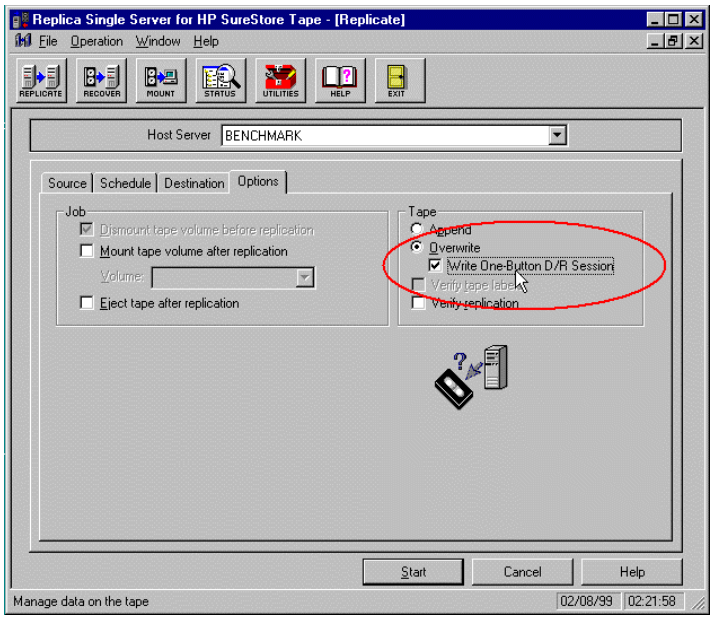


Figure 5: The single check box to turn on HP OBDR functionality.
This implementation is in Stac Replica software.

Since the system is fully backwards-compatible, there can be very few circumstances where this option ever need be turned off. Just possibly, the few minutes added to the backup time for DR tape creation may be significant when the backup window is extremely short, but in this cases it is arguably better to occasionally schedule time specifically for DR tape creation and not to do it during normal backup operations.

Assuming that OBDR is enabled (which it should be, by default), the first full backup of the system will automatically create an OBDR tape, and notify the user that it has completed successfully:

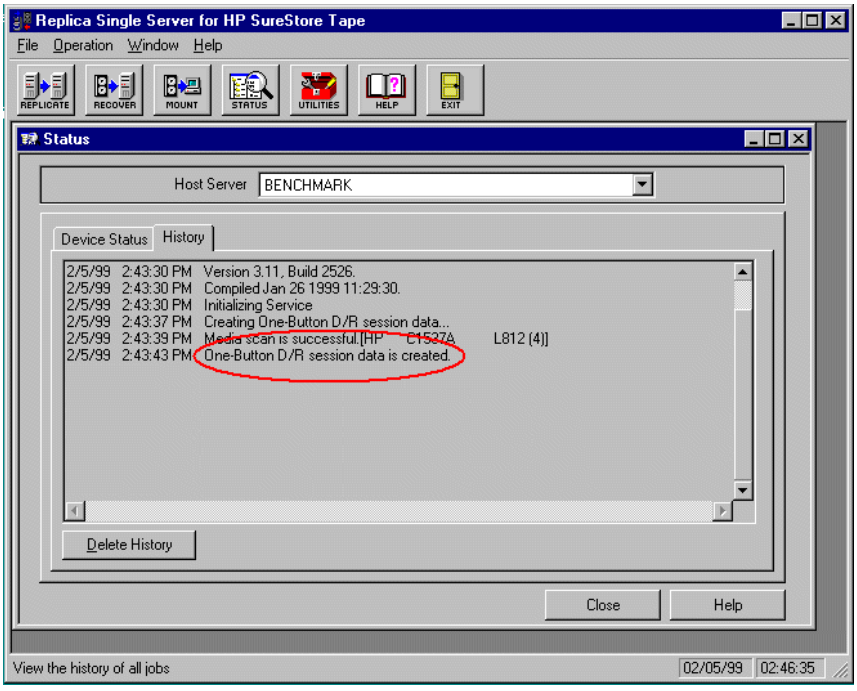


Figure 6: The user is informed that the OBDR backup has completed.

Using OBDR to restore a system

In this scenario, the system has crashed. The hardware has been repaired and now a disaster recovery has been started. The user started the tape drive in DR mode, so that it is now behaving as a CD-ROM drive:

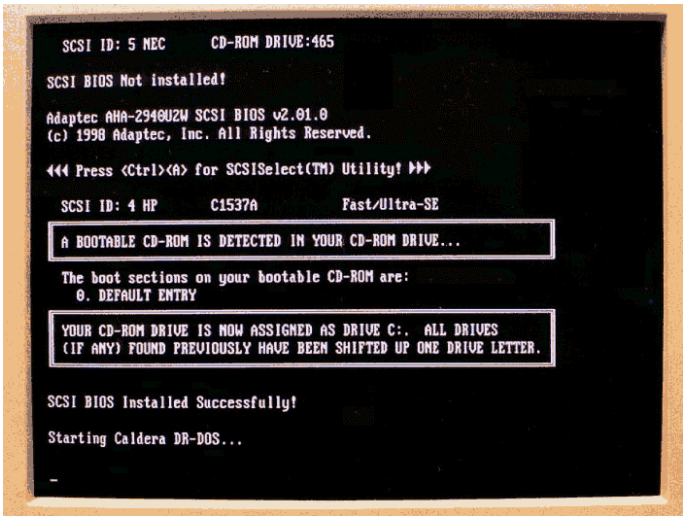


Figure 7: A typical OBDR boot message. It indicates that the tape drive has been detected as a bootable CD-ROM. The line immediately above shows that the tape drive is attached to the third SCSI adapter at ID 4.

Had there been no tape inserted in the drive, the system would have paused once the drive had been detected, waiting for a tape to be inserted. If a backup without an OBDR header was inserted, the tape would have been ejected and the drive would have returned to normal mode.

Since an OBDR tape was loaded, a bootable, minimal operating system is now loaded into memory. As soon as enough functionality has been returned to the system, a disaster recovery information page can be displayed:

Figure 8: The One Button Disaster Recovery welcome screen. (for recoveries).

This screen explains what's going on and helps to prevent the user overwriting their system if they have triggered OBDR by mistake.

Next, the minimum operating system and disaster recovery files are copied to the hard disk, which is made bootable. The system will then reboot back into its usual operating system (for example Windows NT). The restoration will continue by determining how many complete backup sessions there are on tape, and letting the user select the one from which to restore.

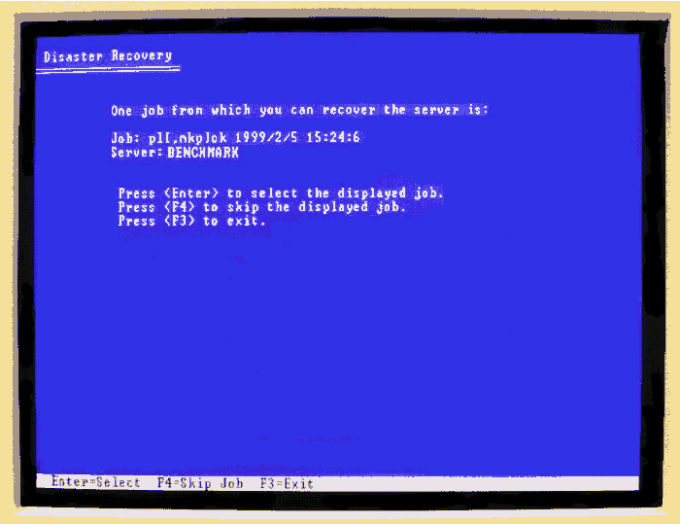


Figure 9: Choosing which session to restore the system from (Stac Replica, using the Windows NT installation engine).

Backups earlier than the most recent can be selected, if they exist on the tape, or the tape can be swapped for another containing the desired session.

Using OBDR tapes in normal operations

There are no special requirements – OBDR tapes are mounted and used just as any other backup tape.

The screen-shot below shows the backup tape used for this white paper mounted as a logical, read-only disk drive by Stac Replica (viewed in Windows' Explorer). In this mode, files can be restored merely by dragging-and-dropping from tape to their desired location on the real hard disks.

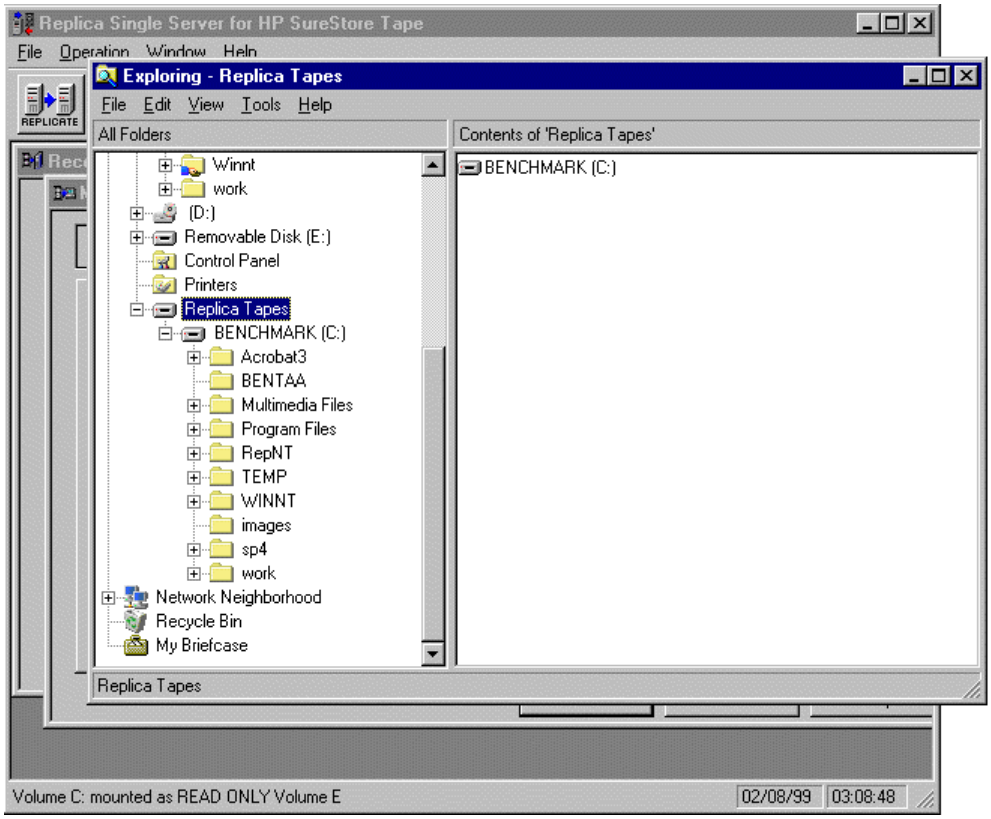


Figure 10:
An HP OBDR tape mounted as a virtual disk.

Obviously, this functionality is specific to the backup software package, in this case Stac Replica, but it illustrates well the transparency of the HP OBDR system. If a basic tape drive had been used instead of one with HP OBDR capability, the tape would have been mounted and accessible in exactly the same way.

OBDR maintenance

Hewlett-Packard One-Button Disaster Recovery tapes must be made either onto a new tape, or when an old one is overwritten from the beginning. This is easy: as outlined above only a single control must be activated to make an OBDR tape at the next backup.

For maintenance of the OBDR information itself, the HP OBDR specification requires that provision is made in the software for automatic, regular updates.

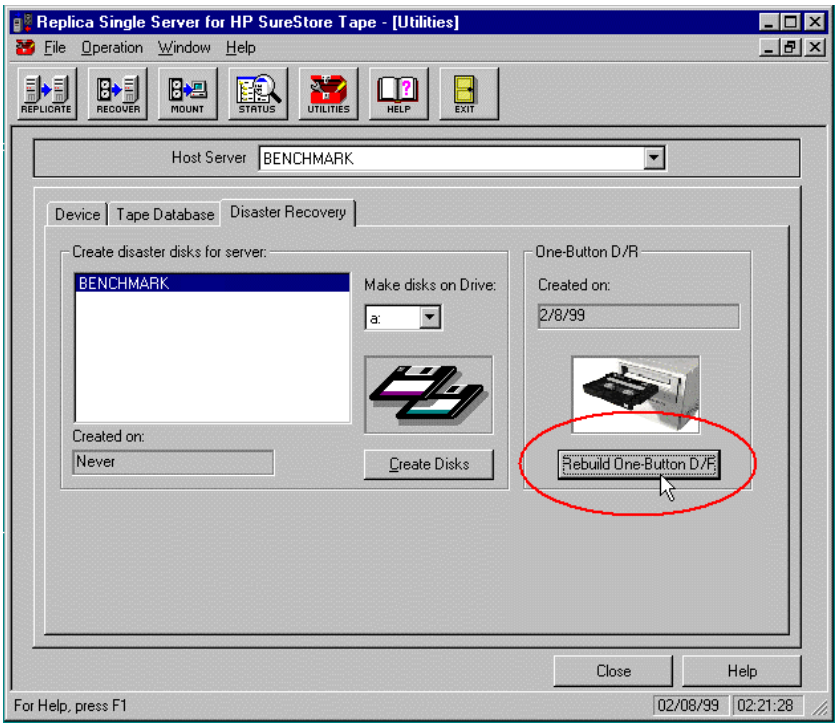


Figure 11: A utility option to force immediate updating of OBDR data.

Any change to the system configuration, such as adding an extra disk, would be automatically reflected in the stored OBDR image. Updating or rebuilding of the DR image file can also be forced manually. This is useful in case the DR image file is accidentally deleted, or requires unexpected replacement, for example after a virus attack. In this case the function is accessible from a Utilities menu.

Appendices

1. About the El Torito format

The *El Torito specification*, developed jointly by IBM and Phoenix Technologies defines how a CD should be structured to hold one or more bootable images. It was originally developed for operating system distribution and multimedia applications, permitting developers to put bootable code for different platforms onto one distribution CD. The target computer can then be booted with a tuned, application-specific operating system (for example, a games engine or multimedia kiosk system). It is often used this way today, and one CD may contain code for, say, both PC and Macintosh versions of the same game, or several similar versions of code, each optimized for different CPU types[iii].

How El Torito works

Booting from an El Torito CD-ROM relies on the BIOS supporting Int13 extensions (support for bootable hard disks). The standard defines three 'modes' or layouts for El Torito CD-ROMs*: Floppy Disk, Hard Disk*, and *No Emulation*:

- *Floppy* and *Hard Disk Emulation* require the host adapter's Int13 handler to translate logical block addressing (LBA) to 'physical' addressing, so that the CD-ROM looks exactly like floppy or hard disk hardware, and is treated as such during the boot process. This functionality was defined primarily as an aid to developers. The image structure stored on CD-ROM can be identical to that on the equivalent floppy or hard disk (using LBA), so an application can be developed and debugged on floppy or hard disk (using standard tools), and ported to CD-ROM at a late stage in the process. The major drawback is the additional BIOS code required – support for the required functions in the SCSI adapter hardware is by no means guaranteed. Furthermore, with the decreasing cost of CD-R and CD-RW technology, creating and testing CD images has become easy to do for developers. These emulations are rarely used today.
- *No Emulation* is the simplest approach. The binary image stored on disk is simply copied sequentially into contiguous main memory and executed, without any attempt by the Int13 handler to emulate a disk structure. The El Torito specification permits up to FFFFh 800-byte sectors to be used on CD for the binary image, allowing the full 640k low memory area of the PC to be loaded with an image.. It is supported by any modern SCSI host adapter with an option ROM (BIOS), and it is required by the *PC 99 System Design Guide*[iv]*,* jointly prepared by Microsoft and Intel as the hardware specification for systems running Microsoft Windows 98 and Windows NT version 5.0 operating systems.

El Torito and OBDR

In practice, all three The *El Torito* emulation modes are used by software writing HP OBDR images. The format is flexible, permitting an image of reasonable size, giving backup software vendors considerable freedom to structure the DR operating system as best suits them.

2. The Bios Boot Specification

This standard was introduced by Phoenix Technologies, to present users with a menu of bootable choices when their system starts. It simplifies boot management, and can prevent accidental booting from CD-ROM (for example, when one is left in the drive by mistake).

Hewlett-Packard has developed an extension to this specification, such that the system will automatically boot by default from a tape drive in OBDR mode. A special boot record identifier, "$DR," is used in the tape drive's CD-ROM emulation. This is detected by the SCSI BIOS automatically, and the system boots from the disaster recovery image on tape, ignoring any other boot options. The Hewlett-Packard extension to the standard has now been adopted by major BIOS manufacturers. Adaptec SCSI cards have incorporated the necessary functionality for some while; those for Symbios Logic BIOSes are included with HP SureStore Tape products, as a courtesy to customers. Upgrades should be available for other recent SCSI cards, from the card manufacturers.

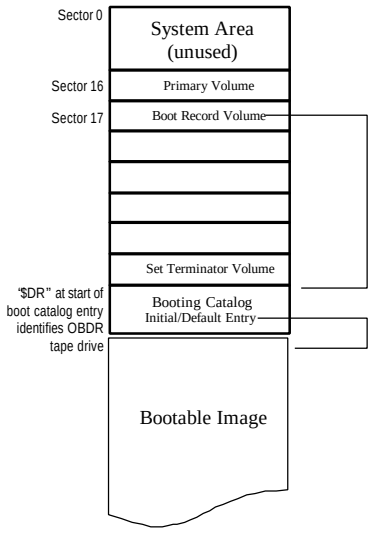


Figure 12: The volume descriptor and boot catalog entry in El Torito / ISO9660 format returned by an HP OBDR tape drive in CD-ROM emulation mode The bootable image itself is created by the software and physically read from tape.

3. Compatibility information

There are two aspects to compatibility with Hewlett-Packard One-Button Disaster Recovery:

- Software support, which is the ability to create suitable OBDR backup tapes and use them to recover a system, and to recognise a tape drive automatically
- The ability of SCSI BIOSes to recognise and communicate with the tape drive correctly when it is operating in OBDR mode.

These are addressed below, but for the most up-to-date connectivity and compatibility information on all HP SureStore tape products, we recommend you visit our Web site at: *http://www.hp.com/go/connect*

Software support

Backup software packages from the following companies are expected to support HP OBDR fully:

- Computer Associates
- Seagate Software
- Stac Software

BIOS support

To ensure correct OBDR functionality, the SCSI host adapter must be at a BIOS revision which correctly supports the El Torito bootable CD-ROM specification. The following BIOS revisions are suitable:

Adaptec:

For 29xx / 39xx series of SCSI host adapter cards, BIOS revision 1.25 and later

Symbios Logic

Bios revisions 4.13.03 and later

System Support

The following Hewlett-Packard systems have been tested and proven to support HP OBDR:

HP NetServer PC servers: E-series, LC-series, LD-series, LH-series[v], LPr[iii], LXr 8000[iii]

HP Kayak PC workstations: XU series, XW series, XA series & XA-s series

HP SureStore DAT autoloaders

At the time of writing, HP SureStore DAT autoloaders do not have HP OBDR functionality built-in. In these products, SCSI commands for the entire device are received through the DAT mechanism's SCSI interface, and the DAT mechanism's microcontroller also manages the robotics. As a consequence, the autoloader firmware requires more flash ROM space than the equivalent for a standalone tape drive, and there is presently insufficient space in the EPROM to add the additional code for OBDR support.

[iii] Microsoft's Windows NT Workstation retail distribution disk is an example of this, containing bootable code for both Intel and Alpha architectures.

[iv] *"PC 99 System Design Guide"* Chapter 11, Section 11.2, Intel Corporation and Microsoft Corporation, with Compaq Computer Corporation, Dell Computer Corporation, Gateway 2000 Inc. and Hewlett-Packard Company, Microsoft Press, Redmond, 1998, ISBN: 0-7356-0518-1

[v] NOTE: These HP NetServers require an additional SCSI host adapter to be fitted. See http://www.hp.com/go/connect for up-to-date information. A BIOS update is in preparation to support OBDR on the embedded Symbios SCSI chipset.