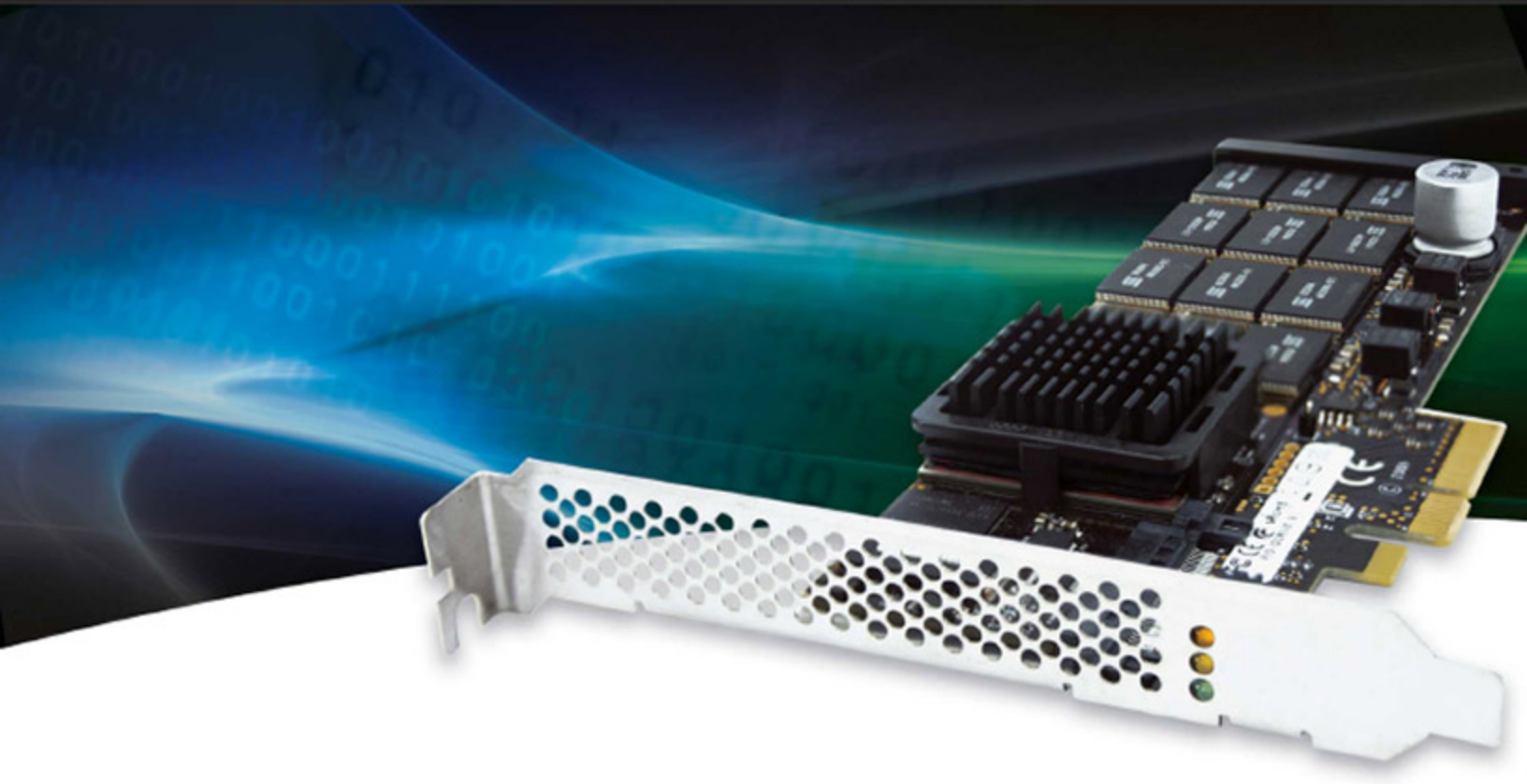

IBM High IOPS Adapter

User Guide - Linux

for Driver Release 2.2.3

5.4.2011

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Part Number D0001565-001_1C

Introduction

Overview

Congratulations on your purchase of an IBM solid-state storage device. This guide explains how to install, troubleshoot and maintain your IBM High IOPS Adapter.

NOTE Throughout this manual, when you see a reference to an "IBM High IOPS Adapter," you may substitute your device.

"IBM High IOPS Duo Adapter" refers to devices with two memory modules, including the IBM High IOPS SD/MD Class SSD PCIe Adapters.

Designed around a revolutionary silicon-based storage architecture, the IBM High IOPS Adapter is the world's most advanced NAND flash storage device, with performance comparable to DRAM and storage capacity on par with today's hard disks—giving you the power to improve storage performance by orders of magnitude. The IBM High IOPS Adapter allows every computer to exceed the I/O performance of an enterprise SAN.

The IBM High IOPS Adapter is a data accelerator designed specifically to improve the bandwidth for I/O-bound applications. The IBM High IOPS Adapter is a no-compromise solution for the toughest computational challenges faced by data centers today, putting it in a league of its own.

About the ioMemory Virtual Storage Layer (VSL)

In addition to the hardware driver, the IBM High IOPS Adapter also includes the ioMemory Virtual Storage Layer (VSL). This is a hybrid of the RAM virtualization subsystem and the disk I/O subsystem, combining the best of both worlds. It appears like a disk to interface well with block-based applications and software. At the same time, it runs like RAM underneath to maximize performance. This provides the following game-changing benefits:

- Performance: The VSL offers direct and parallel access to multiple CPU cores, enabling near linear performance scaling, consistent performance across different read/write workloads, and low latency with minimal interrupts and context switching.
- Extensibility: The VSL enables flash-optimized software development, making each ioMemory module a flexible building block for building a flash-optimized data center.

Flash: Not Just Another Disk Drive

Whether on a PCIe card or in a drive bay, other SSD providers simply treat flash as another disk drive, putting it behind RAID controllers. This approach has the following limitations:

- Reduced performance and reliability
- Increased latency and complexity
- Limited potential for software development and optimization around the flash storage medium

With the ioMemory VSL, the IBM High IOPS Adapter avoids this limiting approach and provides a wealth of performance and optimization possibilities.

IBM High IOPS Adapters

IBM High IOPS Adapter Options

Feature Code	Option Part Number	Description
0096	46M0877	IBM 160GB High IOPS SS Class SSD PCIe Adapter
0097	46M0878	IBM 320GB High IOPS SD Class SSD PCIe Adapter
1649	46M0898	IBM 320GB High IOPS MS Class SSD PCIe Adapter
5985	81Y4519	640GB High IOPS MLC Duo Adapter for IBM System x
A1NE	81Y4535	320GB High IOPS SLC Adapter for IBM system x
A1ND	81Y4539	640GB High IOPS SLC Duo Adapter for IBM System x
A1NC	81Y4531	640GB High IOPS MLC Adapter for IBM System x
A1NB	81Y4527	1.28TB High IOPS MLC Duo Adapter for IBM System x

Memory Attributes

Feature Code	NAND Type [1]	Total Memory	Memory Modules	Module Capacity	Maximum writes per memory module	Maximum writes per card
0096	SLC	160GB	1	160GB	75PB	75PB
0097	SLC	320GB	2	160GB	75PB	150PB [2]
1649	MLC	320GB	1	320GB	4PB	4PB
5985	MLC	640GB	2	320GB	4PB	8PB [2]
A1NE	SLC	320GB	1	320GB	50PB	50PB
A1ND	SLC	640GB	2	320GB	50PB	100PB [2]
A1NC	MLC	640GB	1	640GB	10PB	10PB
A1NB	MLC	1.28TB	2	640GB	10PB	20PB [2]

1. Single Level Cell (SLC), Multi Level Cell (MLC).

2. Assumes uniform distribution of writes across both memory modules.

Performance Attributes

Feature Code	NAND Type [1]	Read Bandwidth	Write Bandwidth	IOPS [2]	Access Latency
0096	SLC	770 MB/s	750 MB/s	123,000	26 µs
0097	SLC	1.5 GB/s	1.5 GB/s	238,000	26 µs
1649	MLC	735 MB/s	510 MB/s	67,000	29 µs
5985	MLC	1.5 GB/s	1.0 GB/s	138,000	29 µs
A1NE	SLC	770 MB/s	790 MB/s	119,000	26 µs
A1ND	SLC	1.5 GB/s	1.5 GB/s	236,000	26 µs
A1NC	MLC	750 MB/s	550 MB/s	74,000	30 µs
A1NB	MLC	1.5 GB/s	1.1 GB/s	150,000	30 µs

1. Single Level Cell (SLC), Multi Level Cell (MLC).
2. IOPS with 75/25 mixed read/write and 512B packet sizes.

System Requirements

Supported Operating Systems

All operating systems must be 64-bit x86 architecture to support the IBM High IOPS Adapter. Running the latest Service Pack of a release is strongly recommended.

Attention UPGRADE WARNING: Version 2.2.3 and later of the driver software, including ioMemory VSL, are not backward-compatible with any driver version earlier than 2.2.3. When you install version 2.2.3 or later, you cannot revert to any driver version before 2.2.3.

Supported Linux Distributions

- Red Hat Enterprise Linux (RHEL) 5, 6
- SUSE Linux Enterprise Server (SLES) 10, 11

NOTE To determine system and operating support for your High IOPS adapter, please see the latest updates on the IBM ServerProven website.
http://www.ibm.com/systems/info/x86servers/serverproven/compat/us/indexsp.html

Hardware Requirements

IBM High IOPS Adapter Requirements

The IBM High IOPS Adapter requires at least:

- A PCI-Express (PCIe) Gen1 x4 slot.
  The IBM High IOPS Adapter is a half-height, half-length, PCIe 1.1 x4 card and for full performance, it must reside in a PCIe slot where at least 4 lanes are electrically active.
- Adequate system cooling.
  To maximize the longevity and performance of an IBM High IOPS Adapter, we recommend at least 300 Linear Feet per Minute (LFM) of airflow through the system.

  In order to protect against thermal damage, the IBM High IOPS Adapter monitors the temperature of its onboard controller chip (This is reported by the *fio-status* command line utility as "Internal temperature").

  The IBM High IOPS Adapter will start throttling write performance once the controller temperature reaches 78°C. If the controller temperature continues to rise, the IBM High IOPS Adapter will shut down once the controller temperature reaches 85°C.

  NOTE If you experience write-performance throttling due to high temperatures, consult your server's documentation for details on increasing airflow within your system .
- Sufficient system memory (RAM).
  The amount of RAM the VSL requires varies according to the average block size written to the device. Using the average block size table below, you can estimate the amount of system memory needed. You can reduce worst-case memory use by formatting your IBM High IOPS Adapter with a 4K sector size and thereby force the average written block size to be 4K or greater.

  Note however, that for many systems, even those formatted with 512 byte sectors, actual memory utilization typically tracks with I/O operations on 4k or larger chunks of data.

At various block sizes, the following table shows the upper limit of RAM that may be required of your system for every 80 GB of IBM High IOPS Adapter storage space used.

Average Written Block Size (bytes)	RAM Usage (MB) per 80GB of storage space
8192	225
4096 (Most common)	425
2048	825
1024	1600
512	3175

For example, if your system is equipped with a IBM High IOPS Duo Adapter, formatted to use 4,096 byte sectors, your system may require as much as:
(425 MB of RAM / 80 GB) x (640 GB) = **3,400 MB (or around 3.32 GB) of system RAM** for use by the IBM High IOPS Duo Adapter driver.

IBM High IOPS Duo Adapter Requirements

In addition to the IBM High IOPS Duo Adapter cooling and RAM requirements given above, the IBM High IOPS Duo Adapter requires at least:

- A PCIe Gen1 x8 slot or a PCIe Gen2 x4 slot.
- A minimum of a *full-height*, half-length slot with a x8 physical connection. For systems with PCI 1.1, all 8 signaling lanes must be active for full IBM High IOPS Duo Adapter performance. For systems with PCIe 2.0, only 4 signaling lanes must be active for full performance.

Software Installation

NOTE Before installing the ioMemory VSL (driver), make sure you have properly installed the IBM High IOPS Adapter(s). Refer to the *IBM High IOPS Adapter Hardware User Guide* for full details.

The ioMemory VSL (driver) requires a 64-bit operating system. See *System Requirements* in the introduction to this guide for a full list of supported operating systems.

Attention After you install this version of the ioMemory VSL, you may need to upgrade the firmware to enable operation. See *Upgrading the Firmware* later in this section for more information

Attention **UPGRADE WARNING:** Version 2.2.3 and later of the driver software, including ioMemory VSL, are not backward-compatible with any driver version earlier than 2.2.3. When you install version 2.2.3 or later, you cannot revert to any driver version before 2.2.3.

NOTE All commands require administrator privileges. Use sudo or log in as "root" to run the install.

Installation Overview

1. If needed, uninstall previous versions of the ioMemory VSL (driver) and the utilities. Instructions for uninstalling current and previous versions of the driver are available in the *Common Maintenance Tasks* section. Once you have uninstalled the packages, return to this page.
2. If needed, install the 64-bit Java Runtime Environment (JRE). See *Installing the JRE*.
3. Install the latest version of the ioMemory VSL. You can install the ioMemory VSL as
   - A pre-compiled RPM package
   - A source-to-build RPM package

     NOTE Follow the instructions under *Installing RPM Packages* to determine whether pre-compiled binary packages are available for your kernel version or if you need to *build the driver package from source*.
4. Install utilities and management software (included in driver installation instructions).
5. *Load the ioMemory VSL* and *Set the Options*.
6. *Upgrade the Firmware* to the latest version, if needed (recommended).

Installing the JRE

The 64-bit Java Runtime Environment (JRE) is required for the driver. To install the JRE,

1. Download the latest Java Runtime Environment from *http://www.java.com*.
2. Click the Free Java Download button to be directed to the correct download for your operating system.
3. Choose a JRE for your operating system that is Version 6 Update 7 or higher, 64-bit.
4. Follow the instructions on *http://www.java.com* and in the JRE installer to complete the JRE installation.

   NOTE The installer package searches for the JRE in standard locations. In some rare cases, if the installation fails, you may need to edit the file /etc/ibm/jre to point to the correct location for the JRE. Should the installation fail for any reason, try running the installer package from a command line so you can see any messages returned.

Installing RPM Packages

To install the IBM High IOPS Adapter Linux driver and utilities on SUSE or RHEL:

1. You will need to install a version of the ioMemory VSL (driver) that is built for your kernel. To determine what kernel version is running on your system, use the following command at a shell prompt:

   ```
   $ uname -r
   ```

2. Compare your kernel version with the binary versions of the driver available at *http://www.ibm.com/*
   - Follow the Quickstart download instructions that come with your device to locate the download files.
   - The files are located in a `.zip` archive. Extract the packages into your download folder.
   - If there is a binary version of the driver that corresponds to your kernel version, use that. **For example**:

     ```
     iomemory-vsl-2.6.18-8.el5-<driver-version>.x86_64.rpm
     ```

   - If there is no binary version of the driver corresponding to your kernel, use the source package. **For example**:

     ```
     iomemory-vsl-source-<driver-version>.x86_64.rpm
     ```

     Exact package names may vary, depending on driver and kernel version chosen.

3. The support `.rpm` packages should also be in the archive downloaded from *http://www.ibm.com*. These packages provide utilities, firmware, and other files.
    - **Examples:**
        - `fio-util-<driver-version>.x86_64.rpm`
        - `fio-firmware-<version>.noarch.rpm`
        - `fio-snmp-agentx-<version>.x86_64.rpm`
        - `iomanager-gui-<version>.noarch.rpm`
        - `iomanager-jre-<version>.x86_64.rpm`
        - `fio-smis-<version>.x86_64.rpm`
        - `fio-snmp-agentx-<version>.x86_64.rpm`
        - `fio-snmp-mib-<version>.x86_64.rpm`
        - `libfio-dev-<version>.x86_64.rpm`
        - `libfio-doc-<version>.x86_64.rpm`
        - `libfusionjni-<version>.0.x86_64.rpm`
        - `fio-common-<driver-version>.x86_64.rpm`
        - `fio-sysvinit-<driver-version>.x86_64.rpm`
4. **Build the driver from source:** This is only required if you cannot find a binary version of the driver. If there is a binary version of the driver, continue to the next step. Otherwise, you must now follow the instructions in *Building the ioMemory VSL from Source*.
5. Change to the directory to where you extracted the installation packages.
6. Enter the following command to install the custom built driver package. Use the package name that you just copied into that directory.

```
rpm -Uvh iomemory-vsl-*.x86_64.rpm
```

7. Enter the following commands to install the support files:

```
rpm -Uvh lib*.rpm
rpm -Uvh fio*.rpm
```

The drivers and utilities are installed to the following locations:

Package Type	Installation Location
Drivers	`/lib/modules/<kernel-version>/extra/fio/iomemory-vsl.ko`
Utilities	`/usr/bin`
Firmware	`/usr/share/fio/firmware`
SNMP MIB	`/usr/share/fio/mib`

8. Continue to *Loading the ioMemory VSL Facility (Driver)* later in the section.

Building the ioMemory VSL from Source

The ioMemory VSL is distributed as a source package. If a binary version of the driver is not available, you will need to build the ioMemory VSL from source.

To build a .rpm installation package:

1. Download current driver source and support packages from *http://www.ibm.com*
   - Follow the Quickstart download instructions that come with your device to locate the download files.
   - The files are located in a `.zip` archive. Extract the packages into your download folder.
2. Change directory to wherever you extracted the source package.
3. Install the prerequisite files for your kernel version.

   On RHEL4, you need `kernel-devel-smp`, `kernel-headers`, (which may already be in the default OS installation) and GCC4.

   ```
   $ yum install kernel-devel-smp kernel-headers gcc rsync
   ```

   On RHEL 5/6, you need `kernel-devel`, `kernel-headers`, (which may already be in the default OS installation) and GCC4.

   ```
   $ yum install kernel-devel kernel-headers gcc rsync
   ```

4. To build an .rpm installation package for the current kernel, run this command:

```
$ rpmbuild --rebuild iomemory-vsl-source-2.2.3.56-1.0.x86_64.rpm
```

When using a .rpm source package for a non-running kernel, run this command:

```
$ rpmbuild --rebuild --define 'rpm_kernel_version
2.6.24.4-64.fc8-x86_64'  iomemory-vsl-source-2.2.3.56-1.0.x86_64.rpm
```

The new `.rpm` package is located in a directory that is indicated in the output from the `rpmbuild` command. To find it, look for the "wrote" line. In the following example, the .rpm packages are located in the `/usr/src/redhat/RPMS/x86_64/` directory.

```
...
Processing files: iomemory-vsl-source-2.2.3.56-1.0.x86_64.rpm
Requires(rpmlib): rpmlib(PayloadFilesHavePrefix) <= 4.0-1
rpmlib(CompressedFileNames) <= 3.0.4-1
Obsoletes: iodrive-driver-source
Checking for unpackaged file(s): /usr/lib/rpm/check-files
/var/tmp/iomemory-vsl-2.2.3.258-root
Wrote:
/usr/src/redhat/RPMS/x86_64/iomemory-vsl-2.6.18-128.el5-2.2.3.56-1.0.x86_
/usr/src/redhat/RPMS/x86_64/iomemory-vsl-source-2.2.3.56-1.0.x86_64.rpm
```

5. Make a note of the .rpm location; you will need this information later in the installation.
6. You have now built installation packages for your distribution and kernel.
7. Copy your custom-built driver installation package (.rpm) into the directory where you extracted the installation packages.
8. Return to the *Installing RPM Packages* section of this guide.

Loading the ioMemory VSL Facility (Driver)

To load the IBM High IOPS Adapter driver:

1. Run this command:

```
$ modprobe iomemory-vsl
```

NOTE The ioMemory VSL automatically loads at system boot. The IBM High IOPS Adapter is now available to the OS as `/dev/fiox`, where *x* is a letter (i.e., a, b, c, etc.).

Attention On SLES11, you must allow unsupported modules for this command to work. Modify the `/etc/modprobe.d/iomemory-vsl.conf` file and uncomment the appropriate line:

```
# To allow the ioDrive driver to load on SLES11, uncomment
below
allow_unsupported_modules 1
```

2. To confirm the IBM High IOPS Adapter is attached, run the `fio-status` utility from the command line. The output lists each drive and its status (attached or not attached).

Attention If the ioMemory device is not automatically attaching, check the /etc/modprobe.d files to see if the `auto_attach` option is turned off (set to 0).

Controlling ioMemory VSL Loading

You can control driver loading either through the init script or through udev.

In newer Linux distributions, users can rely on the udev device manager to automatically find and load drivers for their installed hardware at boot time, though udev can be disabled and the init script used in nearly all cases. For older Linux distributions without this functionality, users must rely on a boot-time init script to load needed drivers. Fusion-io provides an init script in `/etc/init.d/iomemory-vsl` to load the IBM High IOPS Adapter driver in older RHEL4 releases and SLES10 distributions.

Using the init Script

On systems where udev loading of the driver doesn't work, or is disabled, the init script may be enabled to load the driver at boot. On some distros it may be enabled by default.

NOTE The init Script is part of the `fio-sysvinit` package, which must be installed before you can enable it.

You can disable this loading of the IBM High IOPS Adapter ioMemory VSL with the following command:

```
$ chkconfig --del iomemory-vsl
```

To re-enable the ioMemory VSL loading in the init script, use the following command:

```
$ chkconfig --add iomemory-vsl
```

For further details on the init script, see Using the Init Script later in this section.

Using udev

On systems that rely on udev to load drivers, users need to modify an IBM High IOPS Adapter's options file if they want to prevent udev from auto-loading the IBM High IOPS Adapter ioMemory VSL at boot time. To do this, locate and edit the `/etc/modprobe.d/iomemory-vsl.conf` file that already has the following line:

```
# blacklist iomemory-vsl
```

To disable loading, remove the "#" from the line and save the file.

With the blacklist command in place, restart Linux. The IBM High IOPS Adapter ioMemory VSL will not be loaded by udev.

To restore the udev-loading of the ioMemory VSL, replace the "#" to comment out the line.

Attention The version of *udev* on RHEL4u7/CentOS4u7 and earlier do not support the the 'blacklist' directive. Even if the driver is blacklisted as documented, udev will still load the driver.

To blacklist the driver in these versions, put the name of the driver on its own line in the `/etc/hotplug/blacklist` file. Example:
`iomemory-vsl`

On either udev or init script systems

Users can disable the loading of the IBM High IOPS Adapter ioMemory VSL at boot time, and thus prevent the auto-attach process for diagnostic or troubleshooting purposes on either udev or init script systems. Follow the steps in the *Disabling Auto-Attach* section to disable or re-enable the auto-attach functionality.

Alternatively, you can prevent the ioMemory VSL from loading by appending the following parameter at the kernel command line of your boot loader:

```
iodrive=0
```

However, this method is not preferred as it prevents the ioMemory VSL from functioning at all, thus limiting the amount of troubleshooting you can perform.

Using the Init Script

The IBM High IOPS Adapter install process places an init script in `/etc/init.d/iomemory-vsl`. In turn, this script uses the setting options found in the options file in `/etc/sysconfig/iomemory-vsl`. The options file must have ENABLED set (non-zero) for the init script to be used:

```
ENABLED=1
```

The options file contains documentation for the various settings---two of which, `MOUNTS` and `KILL_PROCS_ON_UMOUNT`, are discussed further in the Handling ioMemory VSL Unloads section later in this document.

Mounting Filesystems

Because the IBM High IOPS Adapter ioMemory VSL does not load by the standard means (in the `initrd`, or built into the kernel), using the standard method for mounting filesystems (`/etc/fstab`) for filesystems hosted on the IBM High IOPS Adapter does not work. To set up auto-mounting of a filesystem hosted on an IBM High IOPS Adapter:

1. Add the filesystem mounting command to /etc/fstab as normal.
2. Add the 'noauto' option to etc/fstab as in the two following sample entries.

```
/dev/fioa /mnt/fioa ext3 defaults,noauto 0 0 /dev/fiob1 /mnt/ioDrive ext3
defaults,noauto 0 0
```

(where the `a` in `fioa` can be `a`, `b`, `c`, etc., depending on how many IBM High IOPS Adapters you have installed in the system).

To have the init script mount these drives after the ioMemory VSL is loaded and unmounted and before the ioMemory VSL is unloaded, add a list of mount points to the options file using the procedure documented there.

For the filesystem mounts shown in the earlier example, the line in the options file would look like this:

```
MOUNTS="/mnt/fioa /mnt/iodrive"
```

Handling ioMemory VSL Unloads

Special consideration must be taken during ioMemory VSL unload time. By default, the init script searches for any processes holding open a mounted filesystem and kills them, thus allowing the filesystem to be unmounted. This behavior is controlled by the option `KILL_PROCS_ON_UMOUNT` in the options file. If these processes are not killed, the filesystem cannot be unmounted. This may keep the ioMemory VSL from unloading cleanly, causing a significant delay on the subsequent boot.

Setting the ioMemory VSL Options

This section explains how to set ioMemory VSL options. For more information about setting specific options, see *Appendix C- Using Module Parameters*.

One-Time Configuration

IBM High IOPS Adapter ioMemory VSL options can be set at install time, on the command line of either `insmod` or `modprobe`. For example, to set the `auto_attach` ioMemory VSL option to 0, run the command:

```
$ modprobe iomemory-vsl auto-attach=0
```

This option takes effect only for this load of this ioMemory VSL; subsequent calls to `modprobe` or `insmod` will not have this option set.

Persistent Configuration

To maintain a persistent setting for an option, add the desired option to `/etc/modprobe.d/iomemory-vsl.conf` or a similar file. To prevent the IBM High IOPS Adapters from auto-attaching, add the following line to the `iomemory-vsl.conf` file:

```
options iomemory-vsl auto_attach=0
```

This ioMemory VSL option then takes effect for every subsequent ioMemory VSL load, as well as on autoload of the ioMemory VSL during boot time.

Upgrading the Firmware

With the ioMemory VSL loaded, you need to check to ensure that the IBM High IOPS Adapter's firmware is up-to-date. To do this, run the ***`fio-status`*** command-line utility.

If the output shows that the device is running in minimal mode, download the latest firmware from *http://www.ibm.com/systems/support*, then use the ioManager application or the ***`fio-update-iodrive`*** utility to upgrade the firmware.

NOTE Only driver versions 1.2.4 and higher, with their corresponding firmware versions, can be upgraded to version 2.0 or later. If your driver version is older than 1.2.4, it must be upgraded to 1.2.4 before advancing to a driver/firmware version later than that.

Using the IBM High IOPS Adapter as Swap

To safely use the IBM High IOPS Adapter as swap space requires passing the preallocate_memory kernel module parameter. The recommended method for providing this parameter is to add the following line to the `/etc/modprobe.d/iomemory-vsl.conf` file:

```
options iomemory-vsl preallocate_memory=1072,4997,6710,10345
```

- Where 1072,4997,6710,10345 are serial numbers obtained from ***fio-status***.

A 4K sector size format is required for swap—this reduces the driver memory footprint to reasonable levels. Use IBM High IOPS SSD Management Application or ***fio-format*** to format the IBM High IOPS Adapter with 4k sector sizes.

NOTE Be sure to provide the serial numbers for the ioMemory modules, not the adapter.

NOTE The `preallocate_memory` module parameter is necessary to have the drive usable as swap space. See *Appendix C- Using Module Parameters* for more information on setting this parameter.

Attention You must have 400MB of free RAM per 80GB of IBM High IOPS Adapter capacity (formatted to 4KB block size) to enable the IBM High IOPS Adapter with pre-allocation enabled for use as swap. Attaching an IBM High IOPS Adapter, with pre-allocation enabled, without sufficient RAM may result in the loss of user processes and system instability.

NOTE The `preallocate_memory` parameter is recognized by the ioMemory VSL at load time, but the requested memory is not actually allocated until the specified device is attached.

Using the Logical Volume Manager

The Logical Volume Manager (LVM) volume group management application handles mass storage devices like the IBM High IOPS Adapter if you add the IBM High IOPS Adapter as a supported type:

1. Locate and edit the `/etc/lvm/lvm.conf` configuration file.
2. Add an entry similar to the following to that file:

```
types = [ "fio", 16 ]
```

The parameter "16" represents the maximum number of partitions supported by the drive.

NOTE If using LVM or MD, do not use udev to load the driver. The init script will ensure that the LVM volumes and MD devices are detached before attempting to detach the IBM High IOPS Adapter.

Configuring RAID

You can configure two or more IBM High IOPS Adapters into a RAID array using software-based RAID solutions.

NOTE If you are using RAID1/Mirrored and one device fails, be sure to run `fio-format` on the replacement device (not the existing, good device) before rebuilding the RAID. Following are some examples of some common RAID configurations using the `mdadm` utility.

RAID 0

To create a striped set, where fioa and fiob are the two IBM High IOPS Adapters you want to stripe, run this command:

```
$ mdadm --create /dev/md0 --chunk=256 --level=0 --raid-devices=2 /dev/fioa
/dev/fiob
```

Making the Array Persistent (Existing after Restart)

NOTE On some versions of Linux, the configuration file is in `/etc/mdadm/mdadm.conf`, not `/etc/mdadm.conf`.

Inspect `/etc/mdadm.conf`, if there are one or more lines declaring the devices to inspect, make sure one of those lines specifies "partitions" as an option, if it does not add a new DEVICE line to the file specifying "partitions" like this:

```
DEVICE partitions
```

Also add a device specifier for the IBM High IOPS Adapter:

```
DEVICE /dev/fio*
```

To see if any updates are needed to `/etc/mdadm.conf`, issue the following command:

```
$ mdadm --detail --scan
```

Compare the output of this command to what currently exists in mdadm.conf and add any needed sections to /etc/mdadm.conf. For further details please see the mdadm and mdadm.conf man pages for your distribution.

With these changes, on most systems the RAID 0 array will be created automatically upon restart. However, if you have problems accessing `/dev/md0` after restart, run the following command:

```
$ mdadm --assemble --scan
```

You may also want to disable udev loading of the driver, if needed, and use the init script provided for driver loading. Please see the *Using the Init Script* section of this guide for further details on how to use the init script.

RAID 1

To create a mirrored set using the two IBM High IOPS Adapters `fioa` and `fiob`, run this command:

```
$ mdadm --create /dev/md0 --level=1 --raid-devices=2 /dev/fioa /dev/fiob
```

RAID 10

To create a striped, mirrored array using four IBM High IOPS Adapters (fioa, fiob, fioc, and fiod), run this command:

```
$ mdadm --create /dev/md0 -v --chunk=256 --level=raid10 --raid¬-devices=4
/dev/fioa /dev/fiob /dev/fioc /dev/fiod
```

Building a RAID10 across Multiple IBM High IOPS Duo Adapters

In a RAID10 configuration, sets of two disks are mirrored, and then those mirrors are striped. When setting up a RAID10 across multiple IBM High IOPS Duo Adapters, it is best to make sure that no mirror resides solely on the two ioMemory modules that comprise an IBM High IOPS Duo Adapter.

In order to get the data to lay out properly,

- Use the `--layout=n2` option when creating the RAID10 (though it should be the default)
- Ensure that no two ioMemory modules from the same duo are listed side by side.

The following sample code shows some recommended configurations.

NOTE The following commands assume that all ioMemory modules have been freshly formatted with the `fio-format` utility.

Attention The ordering of the fiox devices is critical.

```
# 2 IBM High IOPS Duo Adapters RAID10
$ mdadm --create --assume-clean --level=raid10 --layout=n2 -n 4 /dev/md0 \
 /dev/fioa /dev/fioc \
 /dev/fiob /dev/fiod
# Mirror groups are: fioa,fioc and fiob,fiod

# 3 IBM High IOPS Duo Adapters RAID10
$ mdadm --create --assume-clean --level=raid10 --layout=n2 -n 6 /dev/md0 \
 /dev/fioa /dev/fiod \
 /dev/fioc /dev/fiof \
 /dev/fioe /dev/fiob

# 4 IBM High IOPS Duo Adapters RAID10
$ mdadm --create --assume-clean --level=raid10 --layout=n2 -n 8 /dev/md0 \
 /dev/fioa /dev/fiod \
 /dev/fioc /dev/fiof \
 /dev/fioe /dev/fioh \
 /dev/fiog /dev/fiob

# 8 IBM High IOPS Duo Adapters RAID10
$ mdadm --create --assume-clean --level=raid10 --layout=n2 -n 16 /dev/md0 \
 /dev/fioa /dev/fiod \
 /dev/fioc /dev/fiof \
 /dev/fioe /dev/fioh \
 /dev/fiog /dev/fioj \
 /dev/fioi /dev/fiol \
 /dev/fiok /dev/fion \
 /dev/fiom /dev/fiop \
 /dev/fioo /dev/fiob
```

Understanding Discard (TRIM) Support

With driver version 2.2.3 and later, Discard (also known as TRIM) is enabled by default.

Discard addresses an issue unique to solid-state storage. When a user deletes a file, the device does not recognize that it can reclaim the space. Instead the device assumes the data is valid.

Discard is a feature on newer filesystem releases. It informs the device of logical sectors that no longer contain valid user data. This allows the wear-leveling software to reclaim that space (as reserve) to handle future write operations.

Discard (TRIM) on Linux

Discard is enabled by default in the Linux ioMemory VSL (driver), version 2.2.3 and later. However, for discard to be implemented, the Linux distribution must support this feature, and discard must be turned on.

In other words, if your Linux distribution supports discard, and discard is enabled on the system, then discard will be implemented on your IBM High IOPS Adapter.

Under Linux, discards are not limited to being created by the filesystem, discard requests can also be generated directly from userspace applications using the kernels discard ioctl.

Attention There is a known issue that ext4 in Kernel.org 2.6.33 or earlier may silently corrupt data when discard is enabled. This has been fixed in many kernels provided by distribution vendors, please check with your kernel provider to be sure your kernel properly supports discard. For more information, see the Errata in *Release Notes for Driver Version 2.2.0*

NOTE On Linux, MD and LVM do not currently pass discards to underlying devices. Thus any IBM High IOPS Adapter that is part of an MD or LVM array will not receive discards sent by the filesystem.

Maintenance

The IBM High IOPS Adapter includes both software utilities for maintaining the device as well as external LED indicators to display its status. You can also install SNMP as a monitoring option.

IBM High IOPS Adapter LED Indicators

The IBM High IOPS Adapter includes three LEDs showing drive activity or error conditions.

Green	Yellow	Amber	Indicates	Notes
O	O	O	Power off	
O	O	●	Power on (Driver not loaded and card not attached)	Load driver and attach card
●	O	O	Power on (Driver loaded but card not attached)	Attach card
●	(Flashing) ●	O	Writing (Rate indicates volume of writes)	Can appear in combination with the Read LED
(Flashing) ●	O	O	Reading (Rate indicates volume of reads)	Can appear in combination with the Write LED
●	●	●	Location beacon	Also appears during a firmware update

Optional External Hard Drive LED

You can also use your computer's existing external HDD access light to indicate a combination of both the reads and writes executing on your IBM High IOPS Adapter. This provides a quick activity check for your device. (See the *IBM High IOPS Adapter Hardware User Guide* for instructions on how to connect this LED to the IBM High IOPS Adapter pinout.)

IBM High IOPS Management Application

Your IBM High IOPS Adapter software includes the ioManager. This application performs the most common operations you need to do with the IBM High IOPS Adapter. In addition, it provides a detailed information screen on each of your installed devices.

The IBM High IOPS Management Application can perform:

- Firmware upgrades
- Low-level formatting
- Attach and detach actions
- Device status and performance information

IBM High IOPS Management Application is installed with the default ioMemory VSL install process. Details on how to install and use IBM High IOPS Management Application appear in the *IBM High IOPS Management Application User Guide*.

Command-line Utilities

Several command-line utilities are included in the installation packages for managing your IBM High IOPS Adapter:

- `fio-attach`
- `fio-beacon`
- `fio-bugreport`
- `fio-detach`
- `fio-format`
- `fio-pci-check`
- `fio-snmp-agentx`
- `fio-status`
- `fio-update-iodrive`

For more information on command-line utilities, see *Appendix A- Utilities Reference*

Common Maintenance Tasks

The following are the most common tasks for maintaining your IBM High IOPS Adapter using command-line utilities. (You can also use the ioManager application to do firmware upgrades as well.)

NOTE All commands require administrator privileges. Log in as "root" or use sudo to run the commands.

NOTE If you came to this section from the *Software Installation* section, *return* to that section after you uninstall previous versions of the driver and utilities.

Unloading the ioMemory VSL

To unload the ioMemory VSL, run this command:

```
$ modprobe -r iomemory-vsl
```

Uninstalling the ioMemory VSL RPM Package

Versions 1.2.x

Remove prior versions of the IBM High IOPS Adapter driver using this command:

```
$ rpm -e iodrive-driver
```

Versions 2.x.x

With versions 2.x.x of the ioMemory VSL, you must specify the kernel version of the package you are uninstalling. Run this command to find the installed driver packages:

```
$  rpm -qa | grep -i iomemory
```

Sample output:

```
iomemory-vsl-2.6.18-194.el5-2.2.0.82-1.0
```

Uninstall the ioMemory VSL by running a command similar to this example (specify the kernel version of the driver you wish to uninstall):

```
$ rpm -e iomemory-vsl-2.6.18-194.el5-2.2.0.82-1.0
```

Uninstalling the ioMemory VSL DEB Package

Versions 1.2.x

Remove prior versions of the IBM High IOPS Adapter driver using this command:

```
$ dpkg -r iodrive-driver
```

Versions 2.x.x

With versions 2.x.x of the ioMemory VSL, you must specify the kernel version of the package you are uninstalling. Run this command to find the installed driver packages:

```
$ dpkg -l | grep -i iomemory
```

Sample output:

```
iomemory-vsl-2.6.32-24-server
```

Uninstall the ioMemory VSL by running a command similar to this example (specify the kernel version of the driver you wish to uninstall):

```
$ dpkg -r iomemory-vsl-2.6.32-24-server
```

Uninstalling the Utilities, Management Application, and Other Support Packages

To uninstall the support RPM packages, run this command (adding or removing package names as needed):

```
$ rpm -e fio-util fio-snmp-agentx fio-common fio-firmware iomanager-gui
iomanager-jre libfio-doc libfusionjni fio-sysvinit
```

To uninstall the support DEB packages, run this command (adding or removing package names as needed):

```
$ dpkg -r fio-util fio-snmp-agentx fio-common fio-firmware iomanager-gui
iomanager-jre libfio-doc libfusionjni fio-sysvinit fio-smis fio-snmp-mib
libfio-dev
```

Disabling Auto-Attach

When the IBM High IOPS Adapter ioMemory VSL is installed, it is configured to automatically attach any devices when the ioMemory VSL is loaded. Sometimes you may want to disable the auto-attach feature. To do so:

1. Edit the following file:

```
/etc/modprobe.d/iomemory-vsl.conf
```

2. Add the following line to that file:

```
options iomemory-vsl auto_attach=0
```

3. Save the file. To re-enable auto-attach, simply edit the file and either remove that line or change it to the following:

```
options iomemory-vsl auto_attach=1
```

Unmanaged Shutdown Issues

Unmanaged shutdowns due to power loss or other circumstances can force the IBM High IOPS Adapter to perform a consistency check during the restart. This may take several minutes or more to complete and is shown by a progress percentage during startup.

Although data written to the IBM High IOPS Adapter is not lost due to unmanaged shutdowns, important data structures may not have been properly committed to the drive. This consistency check repairs these data structures.

Disabling the ioMemory VSL

The ioMemory VSL automatically loads by default when the operating system starts. You can disable ioMemory VSL auto-load for diagnostic or troubleshooting purposes.

To disable ioMemory VSL auto-load:

1. Append the following parameter at the kernel command line of your boot loader:

```
iodrive=0
```

The ioMemory VSL won't load, so the device won't be available to users.

NOTE You can also uninstall the ioMemory VSL to keep it from loading, or move it out of the `/lib/modules/<kernel_version>` directory.

2. Proceed with troubleshooting to correct the problem. If the problem is outdated firmware, use `iodrive=1` to place the ioMemory VSL in minimal mode. You can then use `fio-update-iodrive` or the ioManager application to update the firmware.
3. Use either the `fio-attach` utility or the ioManager application to attach the ioMemory VSL to the operating system.

Appendix A- Utilities Reference

The IBM High IOPS Adapter installation packages include various command-line utilities, installed by default to `/usr/bin`. These provide a number of useful ways to access, test, and manipulate your device.

Utility	Purpose
`fio-attach`	Makes an IBM High IOPS Adapter available to the OS
`fio-beacon`	Lights the IBM High IOPS Adapter's external LEDs
`fio-bugreport`	Prepares a detailed report for use in troubleshooting problems
`fio-detach`	Temporarily removes an IBM High IOPS Adapter from OS access
`fio-format`	Used to perform a low-level format of an IBM High IOPS Adapter
`fio-pci-check`	Checks for errors on the PCI bus tree, specifically for IBM High IOPS Adapters
`fio-snmp-agentx`	SNMP sub-agent that implements the SNMP FUSION-IODRV-MIB for the Fusion-io ioMemory VSL
`fio-status`	Displays information about the device
`fio-update-iodrive`	Updates the IBM High IOPS Adapter's firmware

There are `-h` (Help) and `-v` (Version) options for all of the utilities. Also, `-h` and `-v` cause the utility to exit after displaying the information.

fio-attach

Description

Attaches the IBM High IOPS Adapter and makes it available to the operating system. This creates a block device in `/dev` named `fiox` (where `x` is `a`, `b`, `c`, etc.). You can then partition or format the IBM High IOPS Adapter, or set it up as part of a RAID array. The command displays a progress bar and percentage as it operates.

NOTE In most cases, the ioMemory VSL automatically attaches the device on load and does a scan. You only need to run `fio-attach` if you ran `fio-detach` or if you set the IBM High IOPS Adapter's auto_attach parameter to 0.

Syntax

```
fio-attach <device> [-q, -h, -v]
```

where `<device>` is the name of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM High IOPS Adapter installed on the system.

You can specify multiple IBM High IOPS Adapters. For example, `/dev/fct1 /dev/fct2` indicates the second and third IBM High IOPS Adapters installed on the system. You can also use a wildcard to indicate all IBM High IOPS Adapters on the system. For example, `/dev/fct*`

Option	Description
`-q`	Quiet: disables the display of the progress bar and percentage.

fio-beacon

Description

Lights the IBM High IOPS Adapter's three LEDs to locate the device. You should first detach the IBM High IOPS Adapter and then run `fio-beacon`.

NOTE This utility always turns the LEDs on, unless you specifically use the `-0` option.

Syntax

```
fio-beacon <device> [-0, -1, -p, -h, -v]
```

where `<device>` is the name of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM High IOPS Adapter installed on the system.

Options	Description
`-0`	Off: Turns off the three LEDs
`-1`	On (default): Lights the three LEDs
`-p`	Prints the PCI bus ID of the device at `<device>` to standard output. Usage and error information may be written to standard output rather than to standard error.

fio-bugreport

Description

Prepares a detailed report of the device for use in troubleshooting problems. The results are saved in the `/tmp` directory in the file that indicates the date and time the utility was run.

Example:

```
/tmp/fio-bugreport-20100121.173256-sdv9ko.tar.bz2
```

Syntax

```
fio-bugreport
```

Notes

This utility captures the current state of the device. When a performance or stability problem occurs with the device, run the `fio-bugreport` utility and send the output to *http://www.ibm.com/systems/support* for assistance in troubleshooting.

You are prompted to send an e-mail describing the problem to support@fusionio.com with the bug report file attached.

NOTE Disregard the message about contacting Fusion-io Support; instead, contact *http://www.ibm.com/systems/support*.

Sample Output

```
-bash-3.2# fio-bugreport /tmp/fio-bugreport-20090921.173256-sdv9ko ~
Collecting fio-status -a
Collecting fio-status
Collecting fio-pci-check
Collecting fio-pci-check -v
Collecting fio-read-lebmap /dev/fct0
Collecting fio-read-lebmap -x /dev/stdout/dev/fct0
Collecting fio-read-lebmap -t /dev/fct0
Collecting fio-get-erase-count/dev/fct0
Collecting fio-get-erase-count -b /dev/fct0
Collecting lspci
Collecting lspci -vvvvv
Collecting lspci -tv
Collecting messages file(s)
Collecting procfusion file(s)
Collecting lsmod
Collecting uname -a
Collecting hostname
Collecting sar -r
Collecting sar
Collecting sar -A
Collecting syslog file(s)
Collecting proc file(s)
Collecting procirq file(s)
Collecting dmidecode
Collecting rpm -qa iodrive*
Collecting find /lib/modules
Please send the file /tmp/fio-bugreport-20090921.173256-sdv9ko.tar.bz2
along with your bug report to support@fusionio.com The file is in the /tmp
directory.
```

For example, the filename for a bug report file named `/tmp/fiobugreport-20090921.173256-sdvk0.tar.bz2` indicates the following:

- Date (20090921)
- Time (173256, or 17:32:56)
- Misc. information (`sdv9ko.tar.bz2`)

fio-detach

Description

Detaches the IBM High IOPS Adapter and removes the corresponding `fctx` IBM High IOPS Adapter block device from the OS. The `fio-detach` utility waits until the device completes all read/write activity before executing the detach operation. By default, the command also displays a progress bar and percentage as it completes the detach.

NOTE Before using this utility, ensure that the device you want to detach is not currently mounted and in use.

Syntax

```
fio-detach <device> [-i, -q, -h, -v]
```

where `<device>` is the name of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM High IOPS Adapter installed on the system.

You can specify multiple IBM High IOPS Adapters. For example, `/dev/fct1 /dev/fct2` indicates the second and third IBM High IOPS Adapters installed on the system. You can also use a wildcard to indicate all IBM High IOPS Adapters on the system. For example, `/dev/fct*`

Options	Description
`-i`	Immediate: Causes a forced immediate detach (does not save metadata). This will fail if the device is in use by the OS.
`-q`	Quiet: Disables the display of the progress bar and percentage.

Notes

With version 2.0 and later of the driver, attempting to detach an IBM High IOPS Adapter may fail with an error indicating that the device is busy. This typically may occur if the IBM High IOPS Adapter is part of a software RAID (0,1,5) volume, is mounted, or some process has the device open.

The tools fuser, mount, and lsof can be helpful in determining what is holding the device open.

fio-format

Description

NOTE The IBM High IOPS Adapter ships pre-formatted, so `fio-format` is generally not required except to change the logical size or block size of the device, or to erase user data on the drive.

Performs a low-level format of the board. By default, `fio-format` displays a progress-percentage indicator as it runs.

Attention Use this utility with care, as it deletes all user information on the board.

NOTE Using a larger block (sector) size, such as 4096 bytes, can significantly reduce worst-case IBM High IOPS Adapter host memory consumption. However, some applications are not compatible with non-512-byte

sector sizes.

NOTE If you do not include the `-s` or `-o` options, the drive size defaults to the advertised capacity. If used, the `-s` and `-o` options must include the size or percentage indicators.

Syntax

```
fio-format <device> [-b <size>, -f, -o <size B|K|M|G|T|%>, -q, -s
<device-size>, -y, -h, -v]
```

where `<device>` is the name of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM High IOPS Adapter installed on the system.

Options	Description
`-b <size B|K>`	Set the block (sector) size, in bytes or KiBytes (base 2). The default is 512 bytes. For example: `-b 512B` or `-b 4K` (`B` in `512B` is optional).
`-f`	Force the format size, bypassing normal checks and warnings. This option may be needed in rare situations when `fio-format` does not proceed properly. (The "Are you sure?" prompt still appears unless you use the `-y` option.) This option can only be used with the `-o` option.
`-q`	Quiet mode: Disable the display of the progress-percentage indicator.
`-s <size B|K|M|G|T|%>`	Set the device capacity as a specific size (in TB, GB, or MB) or as a percentage of the advertised capacity: • `T` Number of terabytes (TB) to format • `G` Number of gigabytes (GB) to format • `M` Number of megabytes (MB) to format • `%` Percentage, such as 70% (the percent sign must be included).
`-o <size B|K|M|G|T|%>`	Over-format the device size (to greater than the advertised capacity), where the maximum size equals the maximum physical capacity. If a percentage is used, it corresponds to the maximum physical capacity of the device. (Size is required for the `-o` option; see the `-s` option above for size indicator descriptions.) NOTE Before you use this option, please discuss your use case with Customer Support at *http://www.ibm.com/systems/support*.
`-y`	Auto-answer "yes" to all queries from the application (bypass prompts).

fio-pci-check

Description

Checks for errors on the PCI bus tree, specifically for IBM High IOPS Adapters. This utility displays the current status of each IBM High IOPS Adapter. It also prints the standard PCI Express error information and resets the state.

It is perfectly normal to see a few errors (perhaps as many as five) when fio-pci-check is initially run. Subsequent runs should reveal only one or two errors during several hours of operation.

Syntax

```
fio-pci-check [-d <value>, -f, -i, -r, -v, -y, -h]
```

Options	Description
`-d <value>`	1 = Disable the link; 0 = bring the link up (Not recommended)
`-f`	Scan every device in the system.
`-i`	Print the device serial number. This option is invalid when the ioMemory VSL is loaded.
`-r`	Force the link to retrain.
`-v`	Verbose: Print extra data about the hardware.

fio-snmp-agentx

Description

This utility is an SNMP sub-agent that implements the SNMP FUSION-IODRV-MIB for the Fusion-io ioMemory VSL. fio-snmp-agentx communicates with the SNMP master agent via the agentx protocol.

Syntax

```
fio-snmp-agentx [-c, -f, -l <log file>, -m, -s, -h, -v]
```

Option	Description
`-c <config file>`	This option is not supported for 2.1.0 or later
`-f`	Force the sub-agent to run in the foreground instead of as a daemon.
`-l <log file>`	Log file to use.
`-m`	This option is not supported for 2.1.0 or later
`-s`	Send errors to stderr instead of to syslog.

Configuration File

Field	Setting	Description
`test_mode_enabled`	`true/false`	Enables test mode (must be 'true' to enable the test-mode file) configuration
`testmode_file`	`<filename>`	Pathname of test-mode file. The default is 'testmode.ini' in the startup directory.
`update_delay`	`<msec>`	Sets the rate (in milliseconds) for polling the ioMemory VSL for updated data
`traps_enabled`	`true/false`	Enables traps (default=false)

fio-status

Description

Provides detailed information about the installed devices. This utility operates on either `fctx` or `fiox` devices. The utility depends on running as root and having the ioMemory VSL loaded. If no ioMemory VSL is loaded, a smaller set of status information is returned.

`fio-status` provides alerts for certain error modes, such as a minimal-mode, read-only mode, and write-reduced mode, describing what is causing the condition.

Syntax

```
fio-status <device> [-a, -c, -d, -fk, -h, -v]
```

where `<device>` is the name of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM High IOPS Adapter installed on the system.

If `<dev>` is not specified, `fio-status` displays information for all cards in the system. If the ioMemory VSL is not loaded, this parameter is ignored.

Options	Description
`-c`	Count: Report only the number of IBM High IOPS Adapters installed.
`-d`	Show basic information set plus the total amount of data read and written (lifetime data volumes). This option is not necessary when the -a option is used.
`-fk`	Format key: Force alternate <"key=value"> format output, which may be easier for scripts and parsing programs to read.
`-a`	Print all available information for each device.

Basic Information: If no options are used, `fio-status` reports the following basic information:

- Number and type of cards installed in the system

- Driver version
  Adapter information:
- Adapter type
- Product number
- PCI power limit threshold (if available)
- Connected ioMemory modules
  Block device information:
- Attach status
- Product name
- Product number
- Serial number
- Firmware version
- Size of the device, out of total capacity
- Internal temperature (average and maximum, since ioMemory VSL load) in degrees Centigrade
- Health status: healthy, nearing wearout, write-reduced or read-only
- Reserve capacity (percentage)
- Warning capacity threshold (percentage)

Data Volume Information: If the -d option is used, the following data volume information is reported *in addition* to the basic information:

- Physical bytes written
- Physical bytes read

All Information: If the `-a` option is used, all information is printed, which includes the following information *in addition* to basic and data volume information:

Adapter information:

- Manufacturer number
- Date of manufacture
- Power loss protection status
- PCIe bus voltage (avg, min, max)
- PCIe bus current (avg, max)
- PCIe power limit threshold (watts)

- PCIe slot available power (watts)
- PCIe negotiated link information (lanes and throughput)

Block device information:

- Part number
- Manufacturer's code
- Manufacturing date
- PCIe slot number
- Vendor and sub-vendor information
- Size of the device, out of total capacity
- Format status and sector information (if device is attached)
- FPGA ID and Low-level format GUID
- PCIe slot available power
- PCIe negotiated link information
- Card temperature, in degrees Centigrade
- Internal voltage, avg. and max.
- Auxiliary voltage:, avg. and max.
- Percentage of good blocks, data and metadata
- Lifetime data volume statistics

Error Mode Information: If the ioMemory VSL is in minimal mode, read-only mode, or write-reduced mode when `fio-status` is run, the following differences occur in the output:

- Attach status is "Status unknown: Driver is in MINIMAL MODE:"
- The reason for the minimal mode state is displayed (such as "Firmware is out of date. Update firmware.")
- "Geometry and capacity information not available." is displayed.
- No media health information is displayed.

fio-update-iodrive

NOTE You should back up the data on the IBM High IOPS Adapter prior to any upgrade as a precaution.

Description

Updates the IBM High IOPS Adapter's firmware. This utility scans the PCIe bus for all IBM High IOPS Adapters and updates them. A progress bar and percentage are shown for each drive as the update completes.

Attention It is extremely important that the power not be turned off during a firmware upgrade, as this could cause device failure. If a UPS is not already in place, consider adding one to the system prior to performing a firmware upgrade.

Attention Note that when running multiple upgrades in sequence (such as going from 1.2.1 to 1.2.4 to 2.2.3), it is critical to load the driver after each firmware upgrade step. Otherwise the on-drive format will not be changed, and there will be data loss.

NOTE The default action (without using the `-d` or `-s` option) is to upgrade all IBM High IOPS Adapters with the firmware contained in the `<iodrive_version.fff>` file. Confirm that all devices need the upgrade prior to running the update. If in doubt, use the `-p` (Pretend) option to view the possible results of the update.

NOTE You must detach all IBM High IOPS Adapters before updating the firmware.

Attention Only driver versions 1.2.4 and higher, with their corresponding firmware versions, can be upgraded to version 2.2.3. If your driver version is older than 1.2.4, it must be upgraded to 1.2.4 before advancing to a driver/firmware version later than that.

Attention If you receive an error message when updating the firmware that instructs you to update the midprom information, contact Customer Support.

To update one or more specific drives:

- If the ioMemory VSL is loaded, use the `-d` option with the device number.

Syntax

```
fio-update-iodrive <iodrive_version.fff> [-d, -f, -l, -p, -q, -s, -h, -v]
```

where `<iodrive_version.fff>` is the path and firmware archive file provided by Fusion-io. The default path is `/usr/share/fio/firmware`. This parameter is required.

Options	Description
`-d`	Updates the specified devices (by `fctx`, where *x* is the number of the device shown in `fio-status`). If this option is not specified, all devices are updated. NOTE Use the `-d` or `-s` options with care, as updating the wrong IBM High IOPS Adapter could damage your device.
`-f`	Force upgrade (used primarily to downgrade to an earlier firmware version). If the ioMemory VSL is not loaded, this option also requires the `-s` option. NOTE Use the -f option with care, as it could damage your card.
`-l`	List the firmware available in the archive.
`-p`	Pretend: Shows what updates would be done. However, the actual firmware is not modified.

`-q`	Runs the update process without displaying the progress bar or percentage.
`-s`	Updates the devices in the specified slots using '*' as a wildcard for devices. The slots are identified in the following PCIe format (as shown in lspci): `[[[[<domain>]:]<bus>]:][<slot>][.[<func>]]`

All three external LED indicators light up during the update process.

Appendix B- Monitoring the Health of IBM High IOPS Adapters

This section describes how the health of IBM High IOPS Adapters can be measured and monitored in order to safeguard data and prolong device lifetime.

NAND Flash and Component Failure

An IBM High IOPS Adapter is a highly fault-tolerant storage subsystem that provides many levels of protection against component failure and the loss nature of solid-state storage. As in all storage subsystems, component failures may occur.

By proactively monitoring device age and health, you can ensure reliable performance over the intended product life.

Health Metrics

The ioMemory VSL manages block retirement using pre-determined retirement thresholds. The IBM High IOPS Management Application and the `fio-status` utilities show a health indicator that starts at 100 and counts down to 0. As certain thresholds are crossed, various actions are taken.

At the 10% healthy threshold, a one-time warning is issued. See the 'monitoring' section below for methods for capturing this alarm event.

At 0%, the device is considered unhealthy. It enters *write-reduced* mode, which somewhat prolongs its lifespan so data can be safely migrated off. In this state the IBM High IOPS Adapter behaves normally, except for the reduced write performance.

The IBM High IOPS Adapter will continue to run in *write-reduced* mode. The health indicator will stay at 0%, but eventually the device will enter *read-only* mode – any attempt to write to the IBM High IOPS Adapter causes an error. Some filesystems may require special mount options in order to mount a read-only block device in addition to specifying that the mount should be read-only.

For example, under Linux, `ext3` requires that `"-o ro,noload"` is used, the `"noload"` option tells the filesystem to not try and replay the journal.

Read-only mode should be considered a final opportunity to migrate data off the device, as device failure is more likely with continued use.

The IBM High IOPS Adapter may enter failure mode. In this case, the device is offline and inaccessible. This can be caused by an internal catastrophic failure, improper firmware upgrade procedures, or device wearout.

NOTE For service or warranty-related questions, contact the company you purchased the device from.

NOTE For IBM High IOPS Duo Adapters, these modes are maintained independently for each half of the IBM High IOPS Duo Adapter and not for the IBM High IOPS Duo Adapter as a whole.

Health Monitoring Techniques

`fio-status`: Output from the `fio-status` utility shows the health percentage and drive state. These items are referenced as `"Media status"` in the sample output below.

```
Found 1 IBM High IOPS SS Class SSD PCIe Adapter in this system
Driver version: 2.2.3 build 240
Adapter: IBM High IOPS SS Class SSD PCIe Adapter
...
Media status: Healthy; Reserves: 100.00%, warn at 10.00%; Data: 99.12%
Lifetime data volumes:
   Physical bytes written: 6,423,563,326,064
   Physical bytes read   : 5,509,006,756,312
```

IBM High IOPS Management Application: In the Device Report tab, look for the Reserve Space percentage in the right column. The higher the percentage, the healthier the drive is likely to be.

SNMP/SMI-S: On Windows or Linux, see the corresponding appendix for details on how to configure SNMP or SMI-S health indicators.

The following Health Status messages are produced by the `fio-status` utility:

- Healthy
- Low metadata
- Read-only
- Reduced-write
- Unknown

Software RAID and Health Monitoring

Software RAID stacks are typically designed to detect and mitigate the failure modes of traditional storage media. The IBM High IOPS Adapter attempts to fail as gracefully as possible, and these new failure mechanisms are compatible with existing software RAID stacks. An IBM High IOPS Adapter in a RAID group will fail to receive data at a sufficient rate if a) the drive is in a write-reduced state, and b) it is participating in a write-heavy workload. In this case, the drive will be evicted from the RAID group. A drive in read-only mode will be evicted when write I/Os are returned from the device as failed. Catastrophic failures are detected and handled just as though they are on traditional storage devices.

Appendix C- Using Module Parameters

The following table describes the module parameters you can set by editing the `/usr/modprobe.d/iomemory-vsl.conf` file and changing their values.

NOTE These changes must be completed before the ioMemory VSL is loaded in order to take effect.

Module Parameter	Default (min/max)	Description
`auto_attach`	True	Attach the device on startup.
`fio_dev_wait_timeout_secs`	30	Number of seconds to wait for /dev/fio* files to show up during driver load. For systems not using udev, this should be set to 0 to disable the timeout and avoid an unneeded pause during driver load.
`force_minimal_mode`	False	Force minimal mode on the device.
`parallel_attach`	True	Enable parallel attach of multiple drivers.
`preallocate_memory`	No devices selected	For the selected devices, pre-allocate all memory necessary to have the drive usable as swap space.
`tintr_hw_wait`	0 (0, 255)	Interval (microseconds) to wait between hardware interrupts. Also known as interrupt coalescing. 0 is off.
`use_workqueue`	3 (1 or 3)	Linux only: 3=use standard OS I/O elevators; 0=bypass.

NOTE Other than the `preallocate_memory`, module parameters are global — they apply to all IBM devices in the computer.

Appendix D- Setting Up SNMP

The `fio-snmp-agentx` SNMP agent is an RFC 2741-compliant AgentX sub-agent. It can work with any RFC-compliant SNMP agent, such as Net-SNMP. The master SNMP agent defers queries to `fio-snmp-agentx` for supported MIBs.

SNMP Master Agent

The `fio-snmp-agentx`, provided in the `fio-util` package, requires an already-installed SNMP master agent. The SNMP master agent must support and be configured for AgentX connections (see *http://www.ietf.org/rfc/rfc2741.txt*). The `fio-snmp-agentx` is tested and verified with Net-SNMP, which is the typical SNMP agent provided with most Linux distributions.

There are several agents available that support this functionality. If you choose to use Net-SNMP, then use the instructions in the following sections to configure and launch it.

Launching the SNMP Master Agent

Install the Net-SNMP package using the package manager for your version of Linux.

Red Hat

Use the following command to install Net-SNMP on Red Hat:

```
yum install net-snmp rsync
```

Other Linux Versions

Use the standard system package manager to install the `Net-SNMP` package on your Linux distribution. The `fio-snmp-mib` package places MIB files in `/usr/share/fio/mib`.

Configuring the Master Agent

You can configure the Net-SNMP master agent daemon to set the network communications parameters, security, and other options by using the `snmpd.conf` text file. The location of this file is system-dependent; often it is in `/etc/snmp` or `/usr/share/snmp`.

A simple `snmpd` configuration file might include the following:

```
# set standard SNMP variables
syslocation "Data room, third rack"
syscontact itguy@example.com
# required to enable the AgentX protocol
master agentx
agentxsocket tcp:localhost:705
#set the port that the agent listens on (defaults to 161)
agentaddress 161
# simple access control (some form of access control is required)
rocommunity public
```

Running the Master Agent

Once you install and configure the master agent, you must start or restart the `snmpd` daemon for the new parameters to take effect. You can simply run `snmpd` from its installed location (often `/usr/sbin` – see the `snmpd` man page for options). It typically needs root privileges to run properly. You can also use the `snmpd` startup script in `/etc/init.d or /etc/rc.d/init.d`. If you are concerned about security, use the more advanced SNMPv3 access control instead of the `rocommunity` and `rwcommunity` access control directives as outlined in the relevant man page.

IBM High IOPS SNMP AgentX Subagent

Installing the Fusion-io SNMP Subagent

1. Download the IBM High IOPS SNMP packages from *http://www.ibm.com*. The SNMP packages are part of the support packages available with the driver download.
2. Install the package using your operating systems package manager. For instance, on Red Hat, run the following:

```
rpm -Uvh fio-snmp-*.rpm
```

The IBM High IOPS Adapter SNMP package places its MIB files in `/usr/share/fio/mib`.

Running and Configuring the Fusion-io SNMP Subagent

1. Configure the subagent by creating a fio-snmp-agentx.conf file.
2. Store this .conf file in the directory where the snmpd.conf file is located for the master agent.
3. At a minimum, set the agent network parameters in this file similar to the following:

```
# required to enable the AgentX protocol

agentxsocket tcp:localhost:705
```

This must match the AgentX network parameters in the `snmpd.conf` file for the master agent. For further AgentX configuration information, consult the man pages or visit *http://www.net-snmp.org*.

The `fio-snmp-agentx startup` script will launch automatically at boot time once the installation and configuration is complete.

Manually Running the Fusion-io SNMP Subagent

If you need to run the Fusion-io SNMP Subagent manually, follow these steps:

1. After the SNMP master agent is started, start the subagent by running this command:

   ```
   /usr/bin/fio-snmp-agentx
   ```

   This command launches the IBM High IOPS Adapter subagent using the Net-SNMP configuration file named `fio-snmpagentx.conf`. This file must reside in one of the Net-SNMP configuration directories: `/etc/snmp, /usr/share/snmp`, `/usr/lib/snmp`, or `$HOME/.snmp`. (These paths can be changed; consult the man page for `snmp_config`.)

2. You can now view the IBM High IOPS Adapter management information using an SNMP MIB browser or by using a network management system accessing `FIOioDrv.mib` (in `/usr/share/fio/mib`).

Subagent Log File

The IBM High IOPS Adapter SNMP subagent can maintain a log file regarding its own activities. This file is separate from the MIB, as it includes entries on the subagent's communications with the master agent, including any errors or intermittent issues.

To have the subagent maintain this log file, include the `--l` parameter and a path to the log file as part of the command in running the subagent. For example, this command:

```
fio-snmp-agentx -l /usr/snmp/subagent.log
```

keeps the subagent log file as `subagent.log`, in the `/usr/snmp` directory.

The IBM High IOPS Adapter SNMP subagent is now ready to monitor your device.

Using the SNMP Sample Config Files

When you install SNMP, the following sample config files are available:

- `/usr/share/doc/fio-snmp-agentx/conf/snmpd.conf/` (master agent)
- `/usr/share/doc/fio-snmp-agentx/conf/fio-snmp-agentx.conf/` (sub-agent)

To customize and use the sample config files,

1. Rename your `snmpd.conf file` (such as to `snmpd-orig.conf`) and your `fio-snmp-agentx.conf` file (such as to `fio-snmp-agentx-orig.conf`). These files usually reside in `/etc/snmp` or `/usr/share/snmp`.
2. In the `/usr/share/doc/fio-snmp/conf/` directory, copy the sample `snmpd.conf` file and a sample `fio-snmp-agentx.conf` file to your target SNMP directory.
3. Edit the sample files you copied and save your changes as `snmpd.conf` and `fio-snmp-agentx.conf`.

Enabling SNMP Test Mode

When the SNMP Agentx runs, it reads the `fio-snmp-agentx config` file:

```
######################################################################
# Example config file for fio-snmp-agentx SNMP AgentX subagent.
#
# IBM #

agentxsocket tcp:localhost:705

# test_mode_enabled
# set to 1, true or yes to enable 0, false or no to disable (default: false)
test_mode_enabled true
# traps_enabled
traps_enabled true
# testmode_file
# name of test mode file (default: testmode.ini)
testmode_file testmode.ini

# update_delay
# delay between agent polling requests in milliseconds (default: 250)
update_delay 100

# mib_select
# set to fio for FUSIONIO-IODRV-MIB or cpq for CPQIODRV-MIB (default: fio)
mib_select fio
######################################################################
```

Conditions for test mode are described below.

1. If the Admin has set the `test_mode_enabled` parameter from TRUE to FALSE, the IBM High IOPS SNMP does not try to run test mode. Instead, it continues processing data as usual from the ioMemory VSL, storing the data in the MIB.

2. If the CONF file says that `test_mode_enabled` is TRUE, the SNMP subagent reads the `testmode.ini` is read periodically by the subagent to check for any changes. A sample testmode.ini file is installed in `/usr/share/doc/fio-snmp-agentx/conf`.
3. If the `testmode.ini` file shows the test mode is set to ON, then it engages the test mode.
4. If test mode is ON, the SNMP Agentx reads the next line, `TestModeIndex`, to identify which IBM High IOPS Adapter to test. The number in this parameter is the PCIe device number shown using `fio-status` such as:

   ```
   PCI:01:00.0
   ```

   The first two numerals identify the PCIe bus number (in this case, 01). This bus number is reported in *hexadecimal*, whereas the `TestModeIndex` in the `testmode.ini` file must be specified in decimal. The converted number should be entered into `testmode.ini`. The `TestModeIndex` must be a valid bus number of an IBM High IOPS Adapter installed in the system.

The IBM High IOPS SNMP subagent now replaces any existing ioMemory VSL data it may have (for the IBM High IOPS Adapter specified by TestModeIndex) with any populated fields in the list of parameters. If a field is not populated, Agentx retains the existing data and reports it to the MIB. If there is a value in a field, then the Agentx replaces that data and reports it to the MIB.

The subagent continues in test mode until the `.INI` file parameter is set to OFF. The test mode information is described in the `testmode.ini` file :

```
# SNMP Test Mode sample file.
# These values may be used to test the SNMP subsystem when it is in test
mode.

[SNMP Agent Test Mode]
TestMode                = off
TestModeIndex           = 0

# InfoState: Note that the following states may change, but current
definitions are:
#   0 = unknown
#   1 = detached
#   2 = attached
#   3 = minimal mode
#   4 = error
#   5 = detaching
#   6 = attaching
#   7 = scanning
#   8 = formatting
#   9 = updating firmware
#  10 = attach
#  11 = detach
#  12 = format
#  13 = update
```

```
InfoState                = 2

InfoInternalTemp         = 45
InfoAmbientTemp          = 35
InfoWearoutIndicator     = 2  ; 2=normal, 1=device is wearing out.
InfoWritableIndicator    = 2  ; 2=normal, 1=non-writable, 0=write-reduced,
3=unknown
InfoFlashbackIndicator   = 2  ; 2=normal, 1=flashback protection degraded.

ExtnTotalPhysCapacityU   = 23
ExtnTotalPhysCapacityL   = 215752192
ExtnUsablePhysCapacityU  = 21
ExtnUsablePhysCapacityL  = 7852192
ExtnUsedPhysCapacityU    = 4
ExtnUsedPhysCapacityL    = 782330816
ExtnTotalLogCapacityU    = 18
ExtnTotalLogCapacityL    = 2690588672
ExtnAvailLogCapacityU    = 14
ExtnAvailLogCapacityL    = 3870457856

ExtnBytesReadU       = 18
ExtnBytesReadL       = 3690588672
ExtnBytesWrittenU  = 4
ExtnBytesWrittenL   = 2578550816

InfoHealthPercentage     = 95

InfoMinimalModeReason    = 7            ; 0=unknown, 1=fw out of date,
2=low power,
                                        ; 3=dual plane failure, 5=internal,
6=card limit,
                                        ; 7=not in minimal mode,
8=unsupported OS,
                                        ; 9=low memory

InfoReducedWriteReason   = 0            ; 0=none, 1=user requested, 2=no md
blocks,
                                        ; 3=no memory, 4=failed die,
5=wearout,
                                        ; 6=adapter power, 7=internal,
8=power limit
```

```
InfoMilliVolts           = 12000
InfoMilliVoltsPeak       = 12100
InfoMilliVoltsMin        = 11900
InfoMilliWatts           = 6000
InfoMilliWattsPeak       = 15000
InfoMilliAmps            = 500
InfoMilliAmpsPeak        = 1000

InfoAdapterExtPowerPresent   = 1      ; 1=present, 2=absent

InfoPowerlossProtectDisabled = 2      ; 1=powerloss protection available but
disabled
                                      ; 2=any other powerloss protection

condition
```

SNMP MIB Support

The following SNMP MIB fields are supported in Linux:

fusionIoDimmMibRevMajor	fusionIoDimmInfoReducedWriteReason
fusionIoDimmMibRevMinor	fusionIoDimmInfoMilliVolts
fusionIoDimmMibCondition	fusionIoDimmInfoMilliVoltsPeak
fusionIoDimmInfoIndex	fusionIoDimmInfoMilliVoltsMin
fusionIoDimmInfoStatus	fusionIoDimmInfoMilliWatts
fusionIoDimmInfoName	fusionIoDimmInfoMilliWattsPeak
fusionIoDimmInfoSerialNumber	fusionIoDimmInfoMilliAmps
fusionIoDimmInfoPartNumber	fusionIoDimmInfoMilliAmpsPeak
fusionIoDimmInfoSubVendorPartNumber	fusionIoDimmInfoAdapterType
fusionIoDimmInfoSparePartNumber	fusionIoDimmInfoAdapterPort
fusionIoDimmInfoAssemblyNumber	fusionIoDimmInfoAdapterSerialNumber
fusionIoDimmInfoFirmwareVersion	fusionIoDimmInfoAdapterExtPowerPresent
fusionIoDimmInfoDriverVersion	fusionIoDimmInfoPowerlossProtectDisabled
fusionIoDimmInfoUID	fusionIoDimmInfoInternalTempHigh
fusionIoDimmInfoState	fusionIoDimmInfoAmbientTemp
fusionIoDimmInfoClientDeviceName	fusionIoDimmExtnIndex

fusionIoDimmInfoBeacon	fusionIoDimmExtnTotalPhysCapacityU
fusionIoDimmInfoPCIAddress	fusionIoDimmExtnTotalPhysCapacityL
fusionIoDimmInfoPCIBandwidthCompatibility	fusionIoDimmExtnUsablePhysCapacityU
fusionIoDimmInfoPCIDeviceID	fusionIoDimmExtnUsablePhysCapacityL
fusionIoDimmInfoPCIPowerCompatibility	fusionIoDimmExtnUsedPhysCapacityU
fusionIoDimmInfoPCISubdeviceID	fusionIoDimmExtnUsedPhysCapacityL
fusionIoDimmInfoPCIVendorID	fusionIoDimmExtnTotalLogCapacityU
fusionIoDimmInfoPCISubvendorID	fusionIoDimmExtnTotalLogCapacityL
fusionIoDimmInfoPCISlot	fusionIoDimmExtnAvailLogCapacityU
fusionIoDimmInfoWearoutIndicator	fusionIoDimmExtnAvailLogCapacityL
fusionIoDimmInfoFlashbackIndicator	fusionIoDimmExtnBytesReadU
fusionIoDimmInfoWritableIndicator	fusionIoDimmExtnBytesReadL
fusionIoDimmInfoInternalTemp	fusionIoDimmExtnBytesWrittenU
fusionIoDimmInfoHealthPercentage	fusionIoDimmExtnBytesWrittenL
fusionIoDimmInfoMinimalModeReason	fusionIoDimmExtnFormattedBlockSize

Appendix E- Documentation Permissions

The `AVR bootloader` and the `tree.h` file, which ship in binary form with the driver, contain content that have the following documentation copyright requirements:

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tree.h

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IBM Support

IBM High IOPS Adapter Customer Support is available on the web at the following address:

http://www.ibm.com/systems/support

IBM part number 60Y1444