IBM ioMemory VSL 2.3.10

User Guide for Microsoft Windows

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Introduction

Overview

Congratulations on your purchase of a IBM solid-state storage device. This guide explains how to install, troubleshoot, and maintain the software for your IBM High IOPS Adapters.

NOTE   Throughout this manual, when you see a reference to an **IBM High IOPS Adapter**, you may substitute your particular device(s), such as an IBM High IOPS Adapter or each of the two IBM High IOPS Adapters of an IBM High IOPS Duo Adapter.

Attention   **Products with Multiple Devices**: Some products, such as an IBM High IOPS Duo Adapter, are actually comprised of **multiple IBM High IOPS Adapters**. If your product consists of multiple IBM High IOPS Adapters, you will manage each IBM High IOPS Adapter as an independent device.

For example, if you have an IBM High IOPS Duo Adapter, you can independently attach, detach, and/or format each of the two IBM High IOPS Adapters. Each of the two devices will be presented as an individual device to your system.

About ioMemory Devices

Designed around a revolutionary silicon-based storage architecture, IBM High IOPS Adapters are the world's most advanced NAND flash storage devices, 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. IBM High IOPS Adapters allow every computer to exceed the I/O performance of an enterprise SAN.

IBM High IOPS Adapters are data accelerators designed specifically to improve the bandwidth for I/O-bound applications. They are no-compromise solutions for the toughest computational challenges faced by data centers today, putting them in a league of their own.

About the ioMemory Virtual Storage Layer (VSL)

More than just a hardware driver, the ioMemory® Virtual Storage Layer™ (VSL) is the "secret sauce" that gives IBM High IOPS Adapters their amazing performance. The VSL™ 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.

About Flashback Protection Technology

High IOPS memory devices have a finite life span of writes operations. Over the life of the product, NAND flash will eventually wear out as part of it's normal life cycle. To extend the life of the adapter, Flashback™ redundancy is designed to mitigate the loss of failed memory location without interrupting normal operation.

This real-time NAND flash redundancy works at the chip-level so these losses are handled without sacrificing user capacity, performance, and provides additional protection above and beyond ECC (Error Correction Code) for soft failures.

IBM's Flashback Protection™ technology, with self-healing properties, ensures higher performance, minimal failure, and longer endurance than all other flash solutions.

System Requirements

Please read the *IBM ioMemory VSL Release Notes* for more information on this release.

Hardware Requirements

- **Hardware Requirements**: These depend on your device (including device capacity, generation, and configuration). Please see the *IBM High IOPS Hardware Installation Guide* for requirements on the following:
    - PCIe Slot
    - Cooling
    - Power

- **Supported Devices**: Also see the *IBM High IOPS Hardware Installation Guide* for a list of supported IBM High IOPS Adapters.

    Attention   Second generation adapters are not compatible with this version of the ioMemory VSL. If you have a newer IBM High IOPS Adapter that is not on this list, you may need to upgrade your system and all of your devices to ioMemory VSL 3.x software and firmware versions.

- **RAM Requirements**: The *IBM ioMemory VSL Release Notes* contains memory (RAM) requirements for this version of the software.

Supported Microsoft Windows Operating Systems

- Microsoft Windows 2003 Server 64-Bit (with SP2 or higher)
- Microsoft Windows 2008 Server 64-Bit, R1 (with SP2 or higher)
- Microsoft Windows 2008 Server 64-Bit, R2

Software Installation

Installation Overview

1. If you are installing this version of ioMemory VSL on a system with previous versions of the ioMemory VSL installed, you will need to uninstall the ioMemory VSL software. See the Existing ioMemory VSL Installation section for instructions. Once you have uninstalled the software, continue with the instructions on that page.

2. Install the latest version of the ioMemory VSL.
   NOTE   For information on capturing an installation log for troubleshooting purposes, see the following Microsoft KB article.

3. Upgrade the Firmware to the latest version, if needed (recommended).

4. Configure the device(s) by Adding a File System, Creating a RAID Configuration, etc.

New ioMemory VSL Installation

To install the ioMemory VSL software on a new system:

1. Complete all the installation steps given in the *Hardware Installation Guide*.

2. Log into your computer with an account that has Administrative rights.

3. Download the Windows ioMemory VSL installation program from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174 and save it to your desktop or another convenient directory.

4. Run the ioMemory VSL installation program. The installation program presents a custom setup tree-view with options for installation.

5. Select a type of install by selecting components from the drop-down menus. If you change your mind later, you can use the Repair option in Programs and Features, or Add or Remove Programs in the Control Panel.
   NOTE   Click on each component to view its description. The descriptions will appear to the right of the install tree.

6. Click **Next**.

7. To select a different folder for the installation, browse to the folder and click **OK**. The default folder is `C:\Program Files\IBM HIGH IOPS`.

8. Follow the onscreen prompts to complete the install.

The installation program:

- Creates a folder for the software components (the default path is `C:\Program Files\IBM HIGH IOPS`).

- Installs and loads the ioMemory VSL. (This may require a restart.)

- Installs support for SNMP (if installed, and if Microsoft SNMP is installed and the SNMP service is running).

- Creates a folder for the VSL utilites. The default path is `C:\Program Files\Common Files\VSL Utils`

When the install program creates the ioMemory VSL folder on the drive, it also creates these sub-folders:

- `<VSL-version>\Driver` —for manual installations using Device Manager

- Firmware —contains the latest IBM High IOPS Adapter firmware

- SNMP —contains the SNMP components

- SMIS and SDK —if selected for installation

NOTE   IBM High IOPS Management Application is a free browser-based solution for managing IBM High IOPS Adapter. The IBM High IOPS Management Application installation software and user documentation are also available from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174.

Proceed to the Outdated Firmware Check to continue.

Existing ioMemory VSL Installation

To install the latest ioMemory VSL Windows software on an existing installation,

1. Review the *IBM ioMemory VSL Release Notes* file available for this version of the software for additional steps that may be needed to complete the install.

2. Log in as Administrator or have Administrator rights.

3. Uninstall the existing VSL, utilities, etc., using **Programs and Features**, or **Add or Remove Programs** (depending on your version of Windows), in the **Control Panel**.

4. Restart the computer.
   NOTE   The ioMemory VSL installation program will attempt to remove previous versions of the software, however if it fails and a previous version is removed by the user after the newest version is installed, the ioMemory VSL will no longer load after a restart. In that case, you need to a) run the Repair option in the installation program, from **Programs and Features** (or **Add or Remove Programs**) in the Control Panel, and b) restart the computer.

5. Download the VSL installation program for Windows from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174 to your desktop or a convenient directory.

6. Run the ioMemory VSL installation program. The installation program presents a custom setup tree-view with options for installation.

7. Select a type of install by selecting components from the drop-down menus. If you change your mind later, you can use the Repair option in Programs and Features, or Add or Remove Programs in the Control Panel.

    NOTE   Click on each component to view its description. The descriptions will appear to the right of the install tree.

8. Click **Next**.

9. To select a different folder for the installation, browse to the folder and click **OK**. The default folder is `C:\Program Files\IBM HIGH IOPS`.

    - The installer also creates a folder for the VSL utilites. The default path is `C:\Program Files\Common Files\VSL Utils`

10. Follow the onscreen prompts to complete the install.

11. Choose **Reboot Now** on the finish screen of the installer.

NOTE   IBM High IOPS Management Application is a free browser-based solution for managing IBM High IOPS Adapter. The IBM High IOPS Management Application installation software and user documentation are also available from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174.

Once the system restarts, proceed to the Outdated Firmware Check section to continue.

Silent Install Option

Attention   **Uninstall Previous**: If the you have a version of the ioMemory VSL previously installed, you must uninstall it first (see the information on a **Silent Uninstall** below). You can must manually reboot the computer after installing the new version with the silent install option. This step must be performed prior using any ioMemory VSL utilities or functionality.

If you are installing remotely or with scripts, you can use the silent install option (`/quiet`) when you run the installation program in the command-line interface.

In the command-line interface, navigate to the folder that contains the `.exe` installer file, and run this command:

```
<installname>.exe /quiet
```

Where the `<installname>.exe` is the name of the installer file.

This option installs the ioMemory VSL using its default settings, eliminating the need to "click Next" or select settings during install.

Installing Components

The default command-line installation installs the ioMemory VSL (including the command-line utilities) and the firmware file. You can add additional components using the following command:

```
<installname>.exe /quiet ADDLOCAL=SNMP,SDK,SMIS
```

Remove any component (and leading/trailing comma) that you do not wish to install.

Silent Uninstall

You may silently uninstall the ioMemory VSL with this command:

```
<installname>.exe /uninstall /quiet
```

Outdated Firmware Check

Check Using the Command-line Interface

More information on these command-line utilities is available in <u>Appendix C- Command-line Utilities</u>.

1. Run <u>fio-status</u> and examine the output.
   - If any device is in minimal mode, then the firmware is outdated.

   - If the firmware listed for any device is a lower number than the latest firmware version as noted in the Release Notes, then the firmware is old, but not outdated.

2. If the firmware is old or outdated, update it using the <u>fio-update-iodrive</u> utility.

Check using the Optional GUI Interface

You can use the (optional) IBM High IOPS Management Application GUI program to check for outdated firmware.

To check for outdated or old firmware:

1. Launch IBM High IOPS Management Application and look for any devices that have a warning symbol.

2. Click on any devices with a warning symbol to ensure that the alert is from outdated firmware.

3. Select all devices requiring firmware update and use IBM High IOPS Management Application to update the firmware. Refer to the *IBM High IOPS Management Application User Guide* for details.

To check for old but not outdated firmware:

1. Find the name of the latest firmware version as noted in the *IBM ioMemory VSL Release Notes*.

2. Use IBM High IOPS Management Application to check each IBM High IOPS Adapter's firmware version against the latest.

3. Refer to the *IBM High IOPS Management Application User Guide* for instructions on how to update the firmware.

Device Naming

The IBM High IOPS Adapter receives a name and number as part of the install process for identification. The syntax is `fctx` where x is the number of the PCIe bus where you installed the IBM High IOPS Adapter. Use the IBM High IOPS Management Application to view this bus number, or follow these steps:

1. Choose **Start** > **Control Panel** > **System** > **Hardware** > **Device Manager**.

2. Select **Fusion ioMemory VSL devices**.

3. Click on your IBM High IOPS Adapter in the list. The Properties dialog box appears.
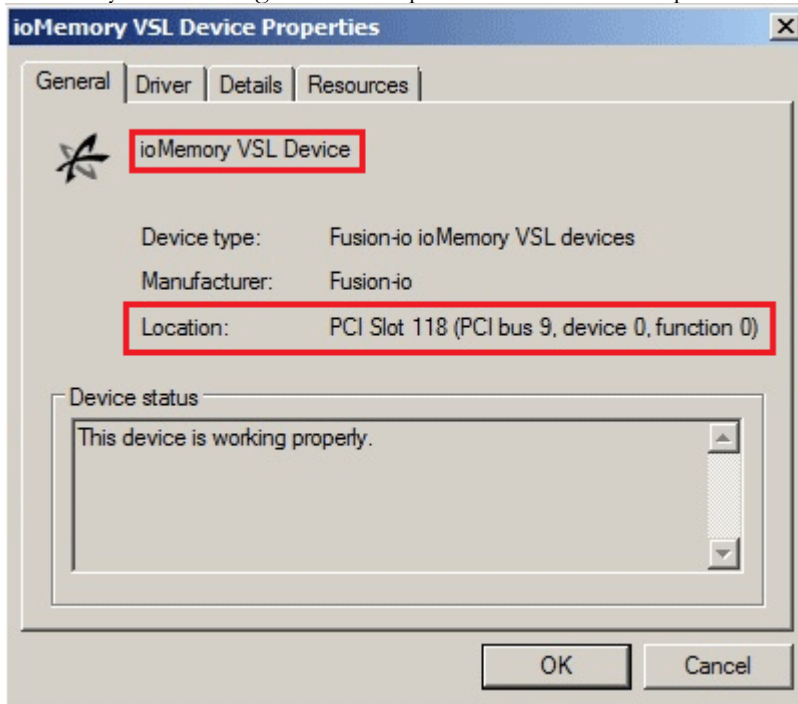
The Location field shows the PCIe bus number for your device (`fct9` in this case).

NOTE The system manufacturer assigns bus numbers, which can range from 0 on up. These numbers may or may not reflect the physical location of the bus. (For example, the second slot from the edge of the motherboard may be Bus 2, but it could also be Bus 16 or another arbitrary number. Checking Device Manager is one way to confirm the specific bus number for your installation. You can also use IBM High IOPS Management Application to view this number as well.)

Adding a File System

With IBM High IOPS Adapter(s) and ioMemory VSL installed, you can now use the Windows Disk Management utility to make your device available to applications. Typically, Windows detects the new device, initializes it, and displays it in Disk Management. You can then add partitions, format a volume, or create a RAID configuration on your IBM High IOPS Adapter using the standard Windows procedures (see the *Windows Disk Management Utility* documentation for more details).

If Windows does not initialize the device, you can do so manually. To initialize an IBM High IOPS Adapter,

1. Select **Start** > **Control Panel**.

2. Click **Administrative Tools**.

3. Click **Computer Management**.

4. Click **Disk Management** in the Storage section of the console tree.

5. Locate and right-click the IBM High IOPS Adapter in the list of storage devices on the right. (If the IBM High IOPS Adapter does not appear in the list, choose **Rescan Disks** from the Action menu. You may also need to restart your computer to display the IBM High IOPS Adapter in the list.)

6. Click **Initialize Disk**.

You can now use the Disk Management Utility to add a file system to your IBM High IOPS Adapter.

Creating a RAID Configuration

You can use your IBM High IOPS Adapter as part of a RAID configuration with one or more additional IBM High IOPS Adapters. To do so, you must format your IBM High IOPS Adapters as dynamic volumes. In turn, you can then use these dynamic volumes to create multi-disk RAID configurations (spanned, striped, mirrored, or RAID 5).

For specific steps to perform a RAID configuration, see the Windows Disk Management Utility documentation for details.

NOTE   If you are using RAID1/Mirroring and one device fails, be sure to run a fio-format on the replacement device (not the remaining good device) before rebuilding the RAID.

Using the Device as Swap

To safely use the IBM High IOPS Adapter as swap space, you need to use the `fio-config` utility to pass a special pre-allocation parameter.

For example:

```
fio-config -p FIO_PREALLOCATE_MEMORY 1072,4997,6710,10345
```

- Where 1072,4997,6710,10345 are device serial numbers obtained from `fio-status` (do not use adapter serial numbers).

A 4K sector size format is required for swap—this reduces the software memory footprint to reasonable levels. See the `fio-format` utility for information on changing the device sector sizes.

NOTE   Be sure to provide the serial numbers for the IBM High IOPS Adapter, not the adapter.

NOTE   `FIO_PREALLOCATE_MEMORY` is necessary to have the device usable as swap space. This will ensure the device is crash-free during operation. See Appendix I- fio-config Options for more information on setting this parameter.

Attention   You must have enough RAM available 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.

Consult the *Release Notes* for RAM requirements with this version of the ioMemory VSL.

NOTE   The `FIO_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.

Understanding TRIM Support

With this version of the ioMemory VSL, TRIM (also known as Discard) is enabled by default on many operating systems.

TRIM 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.

TRIM is a feature on newer operating systems. 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.

For a complete description of TRIM support on Windows, see the TRIM Support appendix.

Attention   Windows does not support TRIM with a RAID 5 configuration.

TRIM on Windows Server 2008 R2

Windows Server 2008 R2 has built-in TRIM support. With thise operating system, IBM High IOPS Adapters work with Windows TRIM commands by default.

TRIM on Windows Server 2003 and Windows Server 2008 R1

Windows TRIM is not built into Windows Server 2003 or Windows Server 2008 R1. However, the IBM TRIM service is installed with the Windows ioMemory VSL and it provides the necessary TRIM operations.

The IBM TRIM service is enabled by default, unless it detects an operating system that supports TRIM (such as Windows Server 2008 R2). You can disable the IBM TRIM service by using the `fio-trim-config` utility. See fio-trim-config for more details.

Maintenance

The ioMemory VSL includes software utilities for maintaining the device. You can also install SNMP as a monitoring option.

Device LED Indicators

The IBM High IOPS Adapter includes three LEDs showing drive activity or error conditions. The LEDs on your device should be similar to this configuration:
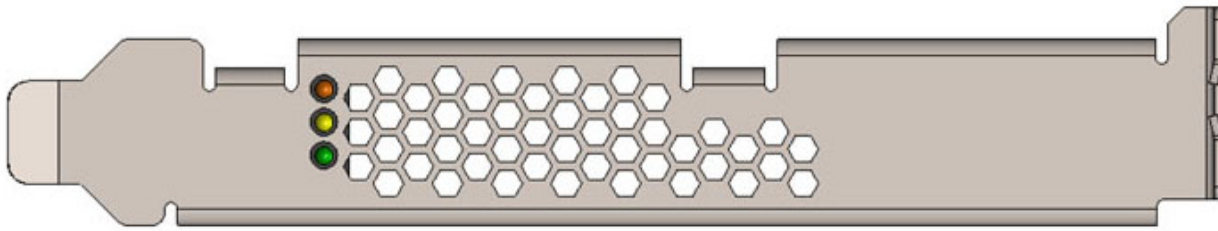
This table explains the information that these LEDs convey:

Green	Yellow	Amber	Indicates	Notes
○	○	○	Power off	
○	○	● (orange)	Power on (Driver not loaded and card not attached)	Load driver and attach card
● (green)	○	○	Power on (Driver loaded but card not attached)	Attach card
● (green)	(Flashing) ● (yellow)	○	Writing (Rate indicates volume of writes)	Can appear in combination with the Read LED
(Flashing) ● (green)	○	○	Reading (Rate indicates volume of reads)	Can appear in combination with the Write LED
● (green)	● (yellow)	● (orange)	Location beacon	

SNMP Support

The ioMemory VSL Windows Setup program provides the option to install support for SNMP. If you choose this option, the Setup program installs the components and modifies the Registry for this support. You must also have the Microsoft Windows SNMP Service installed and running on the computer to receive reports.

Once you run the VSL Windows Setup program, it will stop and start the Windows SNMP Service to recognize the VSL's agent.

If you did not choose to install the SNMP support at Setup, and want to do so later, rerun the Setup program. Choose to install only the SNMP support from the list of items. Once the Setup program completes the install, it will stop and restart the Windows SNMP Service.

For details on using SNMP Test Mode, see Appendix G- SNMP Test Mode and MIB Support.

GUI Management

IBM High IOPS Management Application software is a free browser-based solution for managing IBM High IOPS Adapters. It is also available from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174.

The IBM High IOPS Management Application software can perform many management functions, including:

- Firmware upgrades

- Low-level formatting

- Attach and detach actions

- Device status and performance information

- Configure Swap and Paging

- Generate bug reports

Command-line Utilities

The Windows Setup package also includes several command-line utilities for managing your
http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174:

- `fio-attach`
- `fio-beacon`
- `fio-bugreport`
- `fio-config`
- `fio-detach`
- `fio-format`
- `fio-pci-check`
- `fio-status`
- `fio-sure-erase`
- `fio-trim-config`
- `fio-update-iodrive`

Each of these is described in detail in Appendix C- Command-line Utilities.

Uninstalling the ioMemory VSL

To uninstall the ioMemory VSL,

1. Go to **Start** > **Control Panel**.
2. Click **Programs & Files**.
3. Select the ioMemory VSL (Fusion-io) entry.
4. Click **Uninstall** .

Windows uninstalls the ioMemory VSL folder along with all files and folders.

Upgrading the ioMemory VSL- Non-RAID Configuration

Attention Be sure to read the *IBM ioMemory VSL Release Notes* that comes with each new release as well as these installation instructions to ensure no loss of data when performing upgrades.

To upgrade the ioMemory VSL in a non-RAID configuration:

1. Follow the steps in <u>Uninstalling the ioMemory VSL</u> earlier.

2. Download the latest driver from
   <u>http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174</u>.

3. Either unzip or run the Windows package to copy the files to a convenient directory.

4. Go to **Start** > **Control Panel**.

5. Click **Administrative Tools**.

6. Click **Computer Management**.

7. Click **Device Manager** in the console tree at the left.

8. Expand the Fusion-io Devices item. (Select **System Devices** with pre-1.2.2 drivers.)

9. Right-click the desired device.

10. Click **Update ioMemory VSL Software**. If needed, refer to <u>Appendix B- Manual Installation</u> for details on the remaining steps to install the updated ioMemory VSL.

Windows now detects your IBM High IOPS Adapter(s) with the upgraded ioMemory VSL.

Upgrading the ioMemory VSL with a RAID Configuration

<u>Attention</u>   Be sure to read the *IBM ioMemory VSL Release Notes* that comes with each new release as well as these installation instructions to ensure no loss of data when performing upgrades.

To upgrade the ioMemory VSL with a RAID configuration in place:

1. Shut down any applications that are accessing the IBM High IOPS Adapters.

2. Open the ioMemory VSL Utilities folder. (The default location for this release is `C:\Program Files\Common Files\VSL Utils`.)

3. Double-click the `AutoAttachDisable.reg` file to add a key to the Windows registry. Your IBM High IOPS Adapter now will not automatically attach the next time you restart the computer.

4. Uninstall the VSL software in **Windows Add/Remove Programs**.

5. Restart the computer.

6. Download the latest ioMemory VSL driver package from
   <u>http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174</u>.

7. Unzip and install the ioMemory VSL driver package. While finishing installation, click the "No" button to select a manual restart.

8. Open the VSL Utilities folder. (The default location is `C:\Program Files\Common Files\VSL Utils`)

9. Double-click the `AutoAttachEnable.reg` file to reset the key in the Windows registry. Your IBM High IOPS Adapter will now automatically attach the next time you restart the computer.

10. Update the firmware of the devices. Follow the steps in Upgrading the Device Firmware, which is the next section.

NOTE   Restart the computer after the firmware upgrade is complete. The VSL Check Utility will run at next boot.

Windows now detects your devices in the RAID configuration with the upgraded software.

Upgrading the Device Firmware

Attention   You should upgrade the firmware only if the *System Event Log* reports out-of-date firmware, or if instructed to do so by Customer Support or the *IBM ioMemory VSL Release Notes*.

Viewing the Firmware Version

The firmware version can be found in the Windows Event Log. It is reported by IBM High IOPS Management Application and the `fio-status` command-line utility. For more details, see the *IBM High IOPS Management Application User Guide* or `fio-status` in Appendix C- Command-line Utilities.

Attention   **Upgrade Path**: There is a specific upgrade path that you must take when upgrading IBM High IOPS Adapter. Consult the *IBM ioMemory VSL Release Notes* for this ioMemory VSL release before upgrading IBM High IOPS Adapters.

Performing the Upgrade

Attention   You should back up the data on the device prior to any upgrade as a precaution.

To perform the upgrade, use either IBM High IOPS Management Application (see the *IBM High IOPS Management Application User Guide*) or the `fio-update-iodrive` command-line utility.

Your IBM High IOPS Adapter may have a minimum firmware label affixed (for example, "MIN FW: XXXXXX"). This label indicates the minimum version of the firmware that is compatible with your device.

Attention   Do not attempt to downgrade the firmware on any IBM High IOPS Adapter.

When installing a new IBM High IOPS Adapter along with existing devices, you must upgrade all of the currently installed devices to the latest available versions of the firmware and ioMemory VSL before installing the new devices.

Consult the *IBM ioMemory VSL Release Notes* for this ioMemory VSL release for any upgrade considerations.

Upgrading VMware Guest OS

If you are using your IBM High IOPS Adapter with a VMware guest OS (using VMDirectPathIO), you must cycle the power on the host after you upgrade the device(s). Just restarting the virtual machine won't apply the change.

Defragmentation

The IBM High IOPS Adapter does not need to be defragmented. Some versions of Windows, however, run defragmentation as a scheduled task automatically. If necessary, you should turn off automatic defragmentation.

Unmanaged Shutdown Issues

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

You can cancel this consistency check by pressing Esc during the first 15 seconds after the "Fusion-io Consistency Check" message appears at the prompt. If you choose to cancel the check, however, the IBM High IOPS Adapter(s) will remain unavailable to users until the check is done. (You can perform this check later on using IBM High IOPS Management Application's Attach function).

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

Disabling Auto-Attach

The ioMemory VSL defaults to automatically attach (auto-attach) all installed IBM High IOPS Adapters to the operating system. (If the IBM High IOPS Adapter does not attach, it will not be available to applications or users.) You can disable auto-attach to assist in troubleshooting or diagnostics.

To disable auto-attach:

1. Open the ioMemory VSL Utilities folder. (The default location is `C:\Program Files\Common Files\VSL Utils`).

2. Double-click the `autoattachdisable.reg` file.

3. If you receive a prompt at this point, confirm that you want to modify the registry.

This creates a new DWORD parameter registry key called `AutoAttach` in:

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\fiodrive\Parameters
```

Once you restart your system, your IBM High IOPS Adapter will no longer automatically attach until you re-enable auto attach (see Enabling Auto-Attach)

When you finish troubleshooting the ioMemory VSL issue, use the IBM High IOPS Management Application to attach the IBM High IOPS Adapter(s) and make them available to Windows.

Enabling Auto-Attach

To re-enable auto-attach after disabling it using the method described in <u>Disabling Auto-Attach</u>:

1. Open the ioMemory VSL Utilities folder. (The default location is `C:\Program Files\Common Files\VSL Utils`).

2. Double-click the `autoattachenable.reg` file.

3. If you receive a prompt at this point, confirm that you want to modify the registry.

This resets the AutoAttach parameter in the Registry. The next time you restart your Windows system, your IBM High IOPS Adapter will automatically attach.

IBM High IOPS Adapters provide high bandwidth, and high Input/Output Operations per Second (IOPS), and are specifically designed to achieve low latency.

As IBM High IOPS Adapters improve in IOPS and low latency, the device performance may be limited by operating system settings and BIOS configuration. These settings may need to be tuned to take advantage of the revolutionary performance of IBM High IOPS Adapters.

While IBM devices generally perform well out of the box, this section describes some of the common areas where tuning may help achieve optimal performance.

Disabling DVFS

Dynamic Voltage and Frequency Scaling, or DVFS, are power management techniques that adjust the CPU voltage and/or frequency to reduce power consumption by the CPU. These techniques help conserve power and reduce the heat generated by the CPU, but they adversely affect performance while the CPU transitions between low-power and high-performance states.

These power-savings techniques are known to have a negative impact on I/O latency and maximum IOPS. When tuning for maximum performance, you may benefit from reducing or disabling DVSF completely, even though this may increase power consumption.

DVFS, if available, should be configurable as part of your operating systems power management features as well as within your system's BIOS interface. Within the operating system and BIOS, DVFS features are often found under the Advanced Configuration and Power Interface (ACPI) sections; consult your computer documentation for details.

Limiting APCI C-States

Newer processors have the ability to go into lower power modes when they are not fully utilized. These idle states are known as ACPI C-states. The C0 state is the normal, full power, operating state. Higher C-states (C1, C2, C3, etc.) are lower power states.

While ACPI C-states save on power, they are known to have a negative impact on I/O latency and maximum IOPS. With each higher C-state, typically more processor functions are limited to save power, and it takes time to restore the processor to the C0 state. When tuning for maximum performance you may benefit from limiting the C-states or turning them off completely, even though this may increase power consumption.

If your processor has ACPI C-states available, you can typically limit/disable them in the BIOS interface (sometimes referred to as a Setup Utility). APCI C-states may be part of of the Advanced Configuration and Power Interface

(ACPI) menu; consult your computer documentation for details.

Setting NUMA Affinity

Servers with a NUMA (Non-Uniform Memory Access) architecture require special installation instructions in order to maximize IBM High IOPS Adapter performance. These servers include the IBM x3850 server.

On servers with NUMA architecture, during system boot, the BIOS on some systems will not distribute PCIe slots evenly among the NUMA nodes. Each NUMA node contains multiple CPUs. This imbalanced distribution means that, during high workloads, half or more of the CPUs may remain idle while the the rest are 100% utilized. To prevent this imbalance, you must manually assign ioMemory devices equally among the available NUMA nodes.

For information on setting NUMA affinity, see Appendix J- NUMA Configuration.

Setting the Interrupt Handler Affinity

Device latency can be affected by placement of interrupts on NUMA systems. IBM recommends placing interrupts for a given device on the same NUMA socket that the application is issuing I/O from. If the CPUs on this socket are overwhelmed with user application tasks, in some cases it may benefit performance to move the the interrupts to a remote socket to help load balance the system.

Many operating systems will attempt to dynamically place interrupts for you and generally make good decisions. Hand tuning interrupt placement is an advanced option that requires profiling of application performance on any given hardware. Please see your operating system documentation for information on how to pin interrupts for a given device to specific CPUs.

Appendix A- Troubleshooting Event Log Messages

The Windows System Event Log displays the following messages concerning the IBM High IOPS Adapter: Informational, Warnings, and Errors.

> NOTE   Each IBM High IOPS Adapter is numbered from 0 upwards. These numbers reflect the PCIe bus number where you installed the device. Use the `fio-status` utility or IBM High IOPS Management Application to view this number for your device.

To open the Windows Event Viewer,

1. Click **Start**.

2. Click **Computer** and right-click **Manage**.

3. Expand **Diagnostics**.

4. Expand **Event Viewer**.

5. Expand **Windows Logs**.

6. Select **System**.

Error Messages

The following are common Event Log error messages, along with suggested solutions:

Message	Suggested Solution
Error: ioDrive(x) firmware is too old. The firmware must be updated.	Use the firmware upgrade instructions in the <u>Maintenance</u> section to update the firmware.
Error: ioDrive initialization failed with error code `0xerrorcode` (where `errorcode` is a number that may vary)	1. Reinstall the Windows ioMemory VSL. 2. Remove and reseat the IBM High IOPS Adapter. 3. Remove and insert the IBM High IOPS Adapter in a different PCIe slot
Error: ioDrive was not attached. Use the `fio-attach` utility to rebuild the drive.	This error may appear after an unmanaged shutdown. You can use either the <u>`fio-attach`</u> command-line utility or IBM High IOPS Management Application to re-attach the device. This attach process may take up to ten minutes as the utility performs a consistency check on the device(s).

Warning: ioDrive was not loaded because auto-attach is disabled.	The IBM High IOPS Adapter must attach to the Windows operating system to be available to users and applications. (This attach normally occurs at boot time.) As part of this attach process, the ioMemory VSL checks to see if there is an AutoAttach parameter in the Windows registry. If you create this Registry parameter to disable auto-attach, the attach operation does not complete.

To attach an unattached device,

1. Run the IBM High IOPS Management Application.

2. Select your unattached IBM High IOPS Adapter from the Device Tree.

3. Click **Attach**.

4. Confirm the Attach operation.

   Your device now attaches to the Windows operating system. To re-enable Auto-Attach at boot time, refer to Enabling Auto-Attach in the Maintenance section. |

Informational Messages

The following is a common Event Log informational message:

Message	Additional Information
Affinity not set for ioMemory VSL device fct119 because either WIN_DISABLE_ALL_AFFINITY is set to true or "SetWorkerAffinity119" does not exist in the registry and WIN_DISABLE_DEFAULT_NUMA_AFFINITY is set to true.	When `WIN_DISABLE_ALL_AFFINITY` is set to `0`, the driver will enable interrupt and worker thread affinity in the driver.

When `WIN_DISABLE_ALL_AFFINITY` is set to `1`. the driver will disable all affinity settings. This is an override of any other affinity settings.

Refer to Appendix I- fio-config Options for more information about affinity settings. |

Appendix B- Manual Installation

The Windows Setup program should install your needed ioMemory VSL and software. However, if the ioMemory VSL does not install, you can perform a manual install (or upgrade) using the steps below for Windows Server 2003 or Windows Server 2008.

Manual Installation on Windows Server 2003

The Windows Driver Wizard automatically detects the new IBM High IOPS Adapter and starts to locate its ioMemory VSL after you restart the system. First, Windows will ask if it is okay to connect to Windows update to find the driver. Select **No, not this time** and choose 'Next':

1. If you have not done so, download and run the ioMemory VSL Windows Setup program from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174.

2. Return to the Update Driver dialog.

3. Click **Install from a list or specific location**. Click 'Next'.
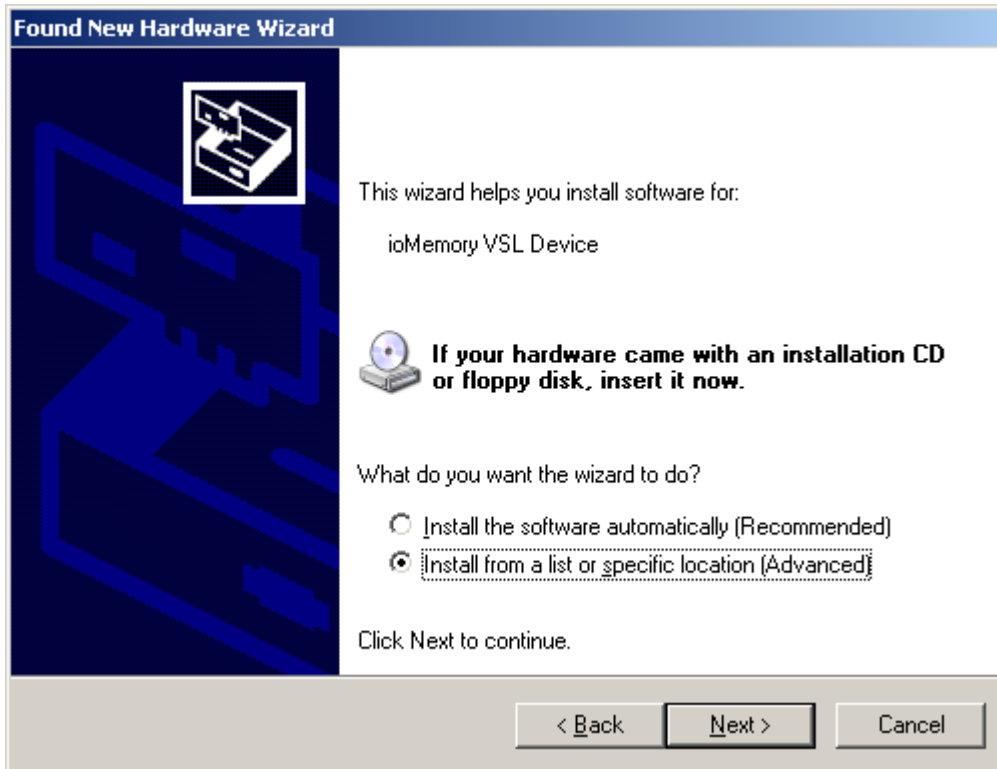
4. Choose **Don't Search. I will choose the driver to install**. Click 'Next'.
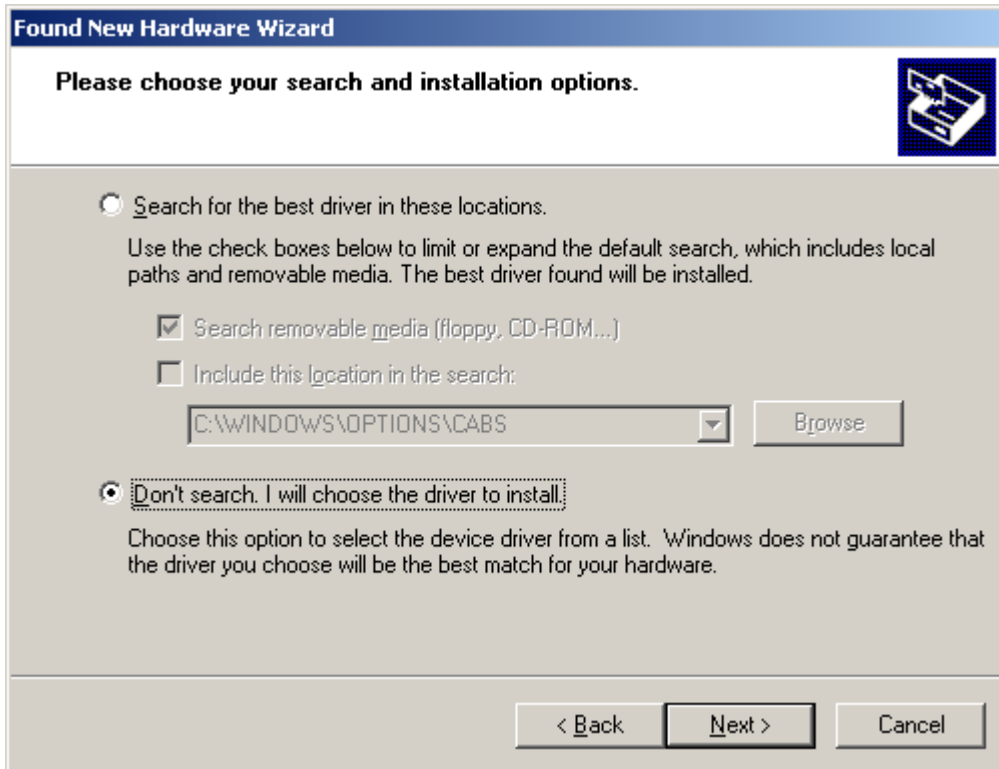
5. Click **Have Disk** to bring up a browsing dialog.

6. Browse to the folder with the ioMemory VSL (the default is `C:\Program Files\IBM HIGH IOPS\<VSL-Version>\Driver`).

7. Click **OK**.

Found New Hardware Wizard

Select the device driver you want to install for this hardware.

Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver you want to install, click Have Disk.

☑ Show compatible hardware

Model
ioMemory VSL Device Version: 2.2.1.16842 [12/9/2010]
ioMemory VSL Device Version: 2.2.1.5747 [12/9/2010]

This driver has an Authenticode(tm) signature.
Tell me why driver signing is important

[Have Disk...]

[< Back] [Next >] [Cancel]

The driver you selected should now be in the compatible hardware window. Make sure it is selected and choose 'Next'.

Found New Hardware Wizard

Select the device driver you want to install for this hardware.

Select the manufacturer and model of your hardware device and then click Next. If you have a disk that contains the driver you want to install, click Have Disk.

☑ Show compatible hardware

Model
ioMemory VSL Device

This driver has an Authenticode(tm) signature.
Tell me why driver signing is important

Have Disk...

< Back   Next >   Cancel

When the ioMemory VSL install completes, Windows displays this message:

Found New Hardware Wizard

Completing the Found New Hardware Wizard

The wizard has finished installing the software for:

ioMemory VSL Device

Click Finish to close the wizard.

< Back   Finish   Cancel

Now you can view the ioMemory VSL in device manager.
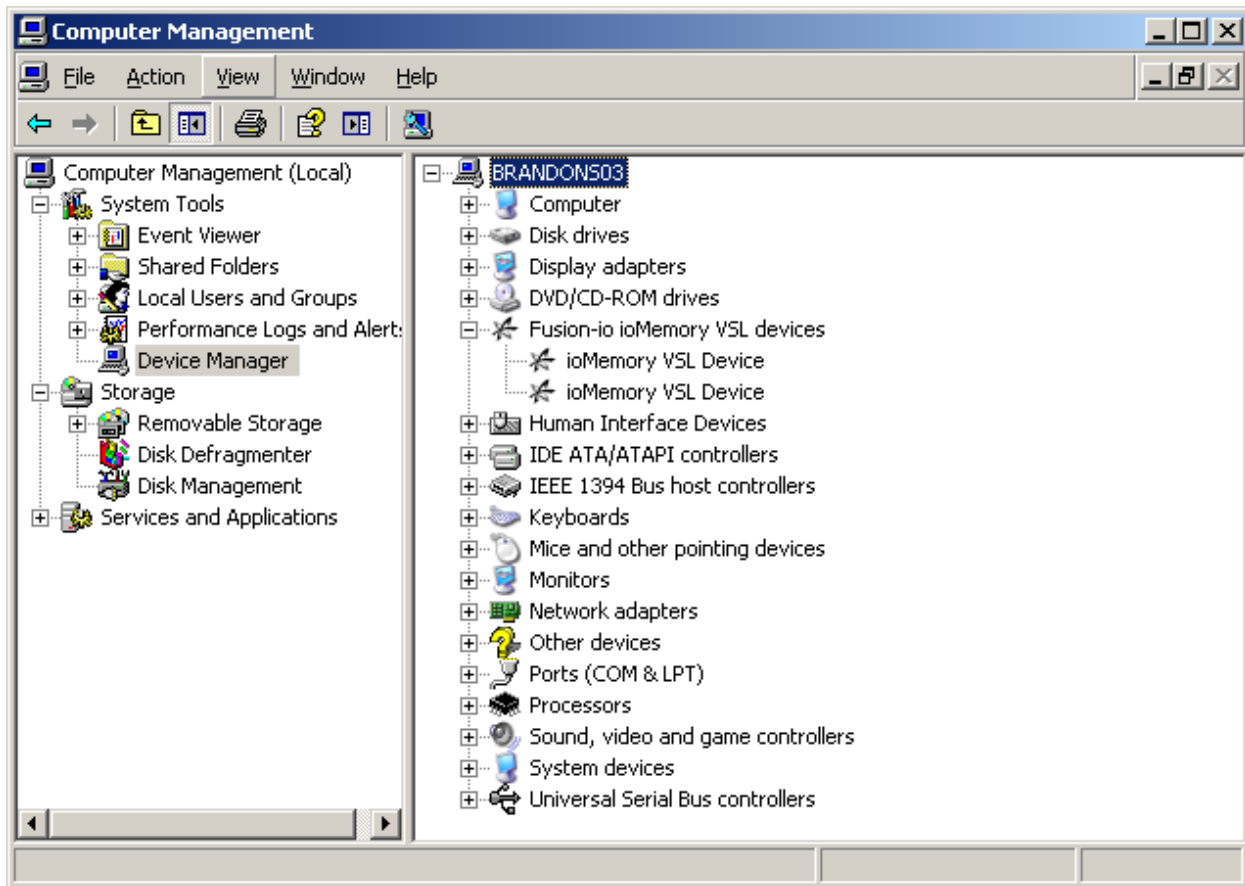
If you need to update your firmware, review the Outdated Firmware Check and Upgrading the Device Firmware sections of this guide.

Manual Install on Windows Server 2008

The Windows Driver Wizard automatically detects the new IBM High IOPS Adapter and starts to locate its driver after you restart the system. First, Windows ask you to locate the software driver.
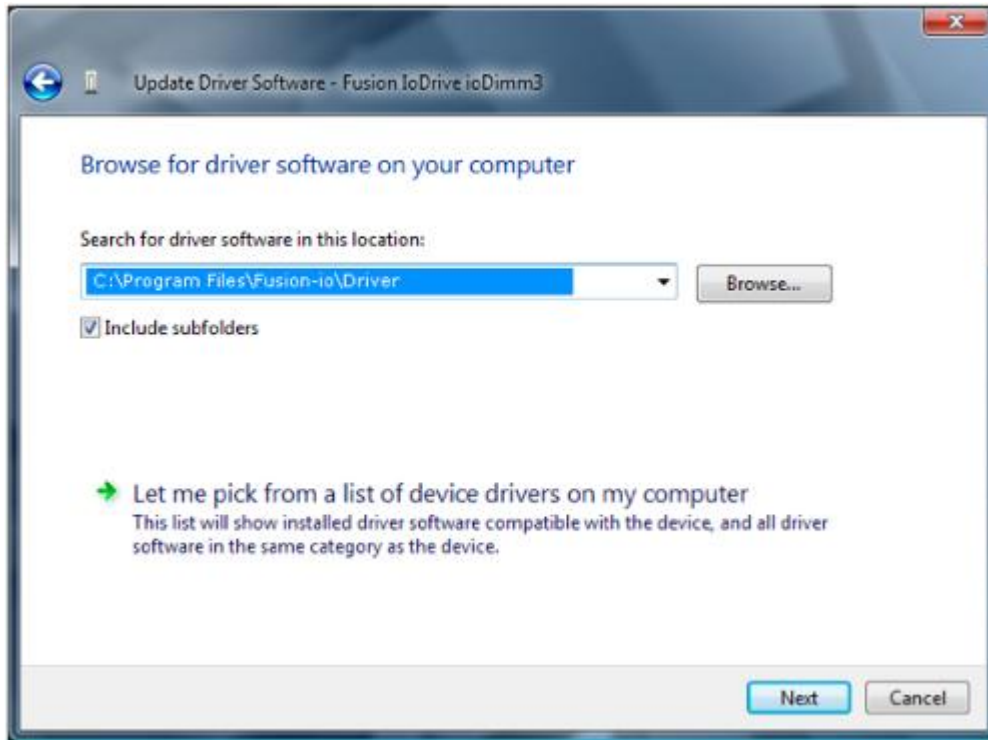
1. Click **Browse** next to the path field. Windows displays a file dialog.

2. Select the folder with the ioMemory VSL (the default is `C:\Program Files\IBM HIGH IOPS\<VSL-Version>\Driver\`).

3. Click **OK**.

4. Click **Next**.

   Windows finds the correct driver and installs the device software. When the driver installation completes,

5. Restart the computer.

6. Proceed to the Outdated Firmware Check section to continue.

Appendix C- Command-line Utilities

The Windows Setup package installs various utilities into the `C:\Program Files\Common Files\VSL Utils` folder, described in the table below.

Attention   There are some additional utilities installed in the `C:\Program Files\Common Files\VSL Utils` directory that are not listed below. Those additional utilities are dependencies (used by the main VSL utilities), and you should not use them directly unless Customer Support advises you to do so.

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-config`	Enables configuration parameters for device operation
`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 Adapter
`fio-status`	Displays information about the device
`fio-trim-config`	Enables or disables the TRIM feature
`fio-update-iodrive`	Updates the IBM High IOPS Adapter's firmware
`fio-sure-erase`	Clears or purges data from the device

NOTE   **Administrator Rights**: The command-line utilities require administrator rights in order to run under Windows (right-click the **Command Prompt** menu item and select **Run as administrator**.)

NOTE   To run these utilities from a command line, you must either change to the directory which contains them (by default, `C:\Program Files\Common Files\VSL Utils`) or add that directory to your system path. As a convenience, if you used the Windows installer then the utilities directory has been added to the system path for you. Otherwise, see the documentation for your version of Windows for information about adding a directory to the system path.

NOTE   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 Windows. You can then partition the IBM High IOPS Adapter, or set it up as part of a RAID array, using the Windows Disk Management utility. This command displays a progress bar and percentage as it completes the attach process.

> 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 ioMemory VSL's auto_attach parameter to 0.
>
> NOTE If the IBM High IOPS Adapter is in minimal mode, then auto-attach is disabled until the cause of the device being in minimal mode is fixed.

Syntax

```
fio-attach <device> [options]
```

where `<device>` is the name given by the ioMemory VSL to your device. This name is `/dev/fctx`, where x indicates the PCIe bus number where you installed the IBM High IOPS Adapter. (For example, the name `/dev/fct4` refers to the IBM High IOPS Adapter installed in PCIe Bus 4 in your Windows system. Use IBM High IOPS Management Application or `fio-status` to view this bus number.)

You can specify multiple IBM High IOPS Adapters. For example, `/dev/fct1 /dev/fct2` indicates the IBM High IOPS Adapters installed in PCIe Buses 1 and 2 in your Windows system.

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> [options]
```

where `<device>` is the name given by the ioMemory VSL to your device. This name is `/dev/fctx`, where x indicates the device number.

Options	Description
-0	Off: (Zero) Turns off the three LEDs
-1	On: 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.

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.

`fio-bugreport` runs several information-gathering utilities and combines the resulting data into a text file. The results are saved in the `utils` directory (default installation path is `C:\Program Files\IBM HIGH IOPS\Utils\`) in a `.cab` file that indicates the date and time the utility was run.

You are then prompted to send an e-mail describing the problem to http://www.ibm.com/systems/support with the bug report file attached.

Sample Output

```
C:\Users\username>"\Program Files\Fusion-io\Utils\fio-bugreport.exe"
Generating bug report. Please wait, this may take a while...
--------------------------------------------
Gathering all Windows Event Logs...DONE
Gathering Fusion-io Windows Event Logs...DONE
Gathering System Information...DONE
Running fio utilities...DONE
Compressing to CAB file...DONE
Bug report has successfully been created:
fio-bugreport-20100222_192621.cab.
Please e-mail this file to support@fusionio.com
```

For example, the filename for a bug report file named `fiobugreport-20090921.192621.cab` indicates the following:

- Date (20090921)

- Time (192621, or 19:26:21)

fio-config

Description

Sets and gets ioMemory VSL configuration parameters for device operation. For a list of parameters, see Appendix I-fio-config Options.

In order for the parameter value(s) to be enforced, you must either reboot the system or first disable and then re-enable all IBM High IOPS Adapters in the **Device Manager**. This will reload the ioMemory VSL with the values(s) enabled.

Syntax

```
fio-config [options] <parameter> <value>
```

where `<parameter>` is the ioMemory VSL parameter you wish to set, and `<value>` is the value you wish to set for the parameter.

Options	Description
`-e`	Enumerate configuration parameter names and values.
`-g <name>`	Get the configuration parameter.
`-p <name>`	Set and make the configuration parameter persistent. **Use this option if you want the parameter setting to remain after a reboot**.
`-s <name>`	Set the configuration parameter in memory only.
`-V`	Print verbose information.
`-v`	Print version information.

fio-detach

Description

Detaches the IBM High IOPS Adapter and removes the corresponding `fctx` 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.

<u>Attention</u>   Before using this utility, ensure that the device you want to detach is not currently mounted and in use.

Syntax

```
fio-detach <device> [options]
```

where `<device>` is the name given by the ioMemory VSL to your device. This name is `/dev/fctx`, where x indicates the device number. (The number reflects the PCIe bus for the IBM High IOPS Adapter.) For example, the name `/dev/fct4` refers to the IBM High IOPS Adapter installed in PCIe Bus 4 in your system. (Use `fio-status` to view this number.)

You can specify multiple IBM High IOPS Adapter. For example, `/dev/fct1 /dev/fct2` indicates the IBM High IOPS Adapters installed in PCIe Buses 1 and 2 in your Windows system.

Options	Description
`-f`	Force: Causes an immediate detach (does not save metadata). <u>Attention</u> Although the `-f` (force) option causes the IBM High IOPS Adapter to detach, even in a RAID setup, it is strongly recommended to take the drives/volume offline using the Windows Disk Management plug-in, then perform the detach. Forcing the detach may result in loss of data.
`-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

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 device is part of a software RAID (0,1,5) volume. Windows refuses the request to detach the drive associated with the IBM High IOPS Adapter because it is part of a RAID volume and may cause the volume to fail. This does not occur with simple volumes (such as a single IBM High IOPS Adapter). To detach in this case, take the volume offline using the Disk Management MMC plug-in application.

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 device.

Performs a low-level format of the device. 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 device.

   NOTE   Using a larger block (sector) size, such as 4096 bytes, can significantly reduce worst-case ioMemory VSL host memory consumption; however, some applications are not compatible with non-512-byte sector sizes.

   NOTE   If you do not include the `-s` option, the device size defaults to the advertised capacity. If used, the `-s` option must include the size or percentage indicators.

Syntax

```
fio-format <device> [options] <device>
```

where `<device>` is the name given by the ioMemory VSL to your device. This name is `/dev/fctx`, where *x* indicates the PCIe bus number where you installed the IBM High IOPS Adapter. (For example, the name `/dev/fct4` refers to the IBM High IOPS Adapter installed in PCIe Bus 4 in your Windows system. Use the IBM High IOPS Management Application or `fio-status` to view this bus number.)

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.)
`-q`	Quiet mode: Disable the display of the progress-percentage indicator.
`-s <size 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.) Attention Before you use this option, please discuss your use case with Customer Support by contacting 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 Adapter. 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.

> NOTE   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.

Attention   The ioMemory VSL *must* be loaded to run this utility. Some PCI errors cannot be reset in Windows.

Syntax

```
fio-pci-check [options]
```

Options	Description
-d <value>	1 = Disable the link; 0 = bring the link up
-f	Scan every device in the system.
-r	Force the link to retrain.
-v	Verbose: Print extra data about the hardware.
-y	"Yes" is forced when the user is asked to continue.

fio-status

Description

Provides detailed information about the installed IBM High IOPS Adapters. 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>] [options]
```

where `<device>` is the name given by the ioMemory VSL to your device. This name is `/dev/fctx`, where x indicates the device number. (The number reflects the PCIe bus for the IBM High IOPS Adapter.) For example, the name `/dev/fct4` refers to the IBM High IOPS Adapter installed in PCIe Bus 4 in your system. (fio-status displays this number.)

If <dev> is not specified, `fio-status` displays information for all devices 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
- Software version

Adapter information:

- Adapter type
- Product number
- External Power Supply
- PCI power limit threshold (if available)
- Connected IBM High IOPS Adapters

Block device information:

- Attach status
- Product name
- Product number
- Serial number
- PCIe slot 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

- 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-sure-erase

Attention   As a best practice, do not use this utility if there are any IBM High IOPS Adapters installed in the system that you do not want to clear or purge. First remove any devices that you do not want to accidentally erase. Once the data is removed with this utility it is gone forever. **It is not recoverable.**

Attention   Before you use this utility, be sure to back up any data that you wish to preserve.

NOTE   After using `fio-sure-erase`, format the device using <u>fio-format</u> before using the device again.

Attention   If the device is in Read-only mode, perform a format using `fio-format` before running `fio-sure-erase`. If the device is in Minimal mode, then `fio-sure-erase` cannot erase the device. Updating the firmware may take the device out of Minimal Mode. If the device remains in Minimal mode, contact Customer Support at <u>http://www.ibm.com/systems/support</u> for further assistance.

In order to run `fio-sure-erase`, the block device **must be detached**. See the <u>fio-detach</u> section for more information.

Description

The `fio-sure-erase` is a command-line utility that securely removes data from IBM High IOPS Adapters. It complies with the "Clear" and "Purge" level of destruction from the following standards:

1. DOD 5220.22-M - Comply with instructions for Flash EPROM

2. NIST SP800-88- Comply with instructions for Flash EPROM

See below for more information on Clear and Purge support.

Registry Requirement

On Windows, a registry key must be created to configure the driver for ECC-bypass mode:

1. Locate the following key:

```
HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\fiodrive\Parameters
```

2. Create a DWORD key underneath it called "BypassECC" and set the value to "1".

3. Restart the computer before running the utility.

Syntax

```
fio-sure-erase [options] <device>
```

Where `<device>` is the name given by the ioMemory VSL to your device. This name is `/dev/fctx`. For example, the name `/dev/fct4` refers to the IBM High IOPS Adapter installed in PCIe Bus 4 in your Windows system. Use `fio-status` to view this bus number.

> NOTE **Products with Multiple Devices**: `fio-sure-erase` works on individual IBM High IOPS Adapters. For example, if you are planning to purge an IBM High IOPS Duo Adapter, you will need to perform this operation on each of the product's two IBM High IOPS Adapters.

Options	Description
`-p`	Purge instead of Clear: performs a write followed by an erase. For more information on Purge, see below. Attention Purging the device may take hours to accomplish, depending on the size of the device that needs to be purged.
`-y`	No confirmation: do not require a yes/no response to execute the utility.
`-q`	Quiet: do not display the status bar.

> NOTE   If you run `fio-sure-erase` with no options, a Clear is performed. For more information, see below.

Each block of memory consists of uniform 1 bits or 0 bits.

Clear Support

A "Clear" is the default state of running `fio-sure-erase` (with no options), and refers to the act of performing a full low-level erase (every cell pushed to "1") of the entire NAND media, including retired erase blocks.

Metadata that is required for operation will not be destroyed (media event log, erase counts, physical bytes read/written, performance and thermal history), but any user-specific metadata will be destroyed.

The following describes the steps taken in the Clear operation:

1. Creates a unity map of every addressable block (this allows `fio-sure-erase` to address every block, including previously unmapped bad blocks).

2. For each block, performs an erase cycle (every cell is pushed to "1").

3. Restores the bad block map.

4. Formats the device (the purpose of this is to make the device usable again, the utility erases all of the headers during the clear).

Purge Support

A "Purge" is implemented by using the `-p` option with `fio-sure-erase`. Purge refers to the act of first overwriting the entire NAND media (including retired erase blocks) with a single character (every cell written to logical "0"), and then performing a full chip erase (every cell pushed to "1") across all media (including retired erase blocks).

Metadata that is required for operation will **not** be destroyed (media event log, erase counts, physical bytes read/written, performance and thermal history), but any user-specific metadata will be destroyed.

The following describes the steps taken in the Purge operation:

1. Creates a unity map of every addressable block (this allows `fio-sure-erase` to address every block, including previously unmapped bad blocks).

2. For each block, performs a write cycle (every cell written to "0").

3. For each block, performs an erase cycle (every cell pushed to "1").

4. Restores the bad block map.

5. Formats the drive (the purpose of this is to make the drive usable again, the utility erases all of the headers during the clear).

fio-trim-config

Description

Enables or disables the TRIM feature (Windows service), which reclaims available space from the file system. It is generally recommended that TRIM be enabled for best performance. TRIM is enabled by default. Running this utility with no options displays the current TRIM status.

NOTE   This utility affects all IBM High IOPS Adapters in the system. You cannot enable or disable TRIM for only selected devices. Settings take place immediately, there is no need to reboot the system or the device.

Syntax

```
fio-trim-config [options]
```

Options	Description
-d	Disable TRIM on this computer.
-e	(Default) Enable TRIM on this computer.

fio-update-iodrive

Attention   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 device 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 firmware upgrades in sequence, 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.

Attention   Do not use this utility to downgrade the IBM High IOPS Adapter to an earlier version of the firmware. Doing so may result in data loss and void your warranty.

Attention   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.

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

Attention   **Upgrade Path**: There is a specific upgrade path that you must take when upgrading IBM High IOPS Adapter. Consult the *IBM ioMemory VSL Release Notes* for this ioMemory VSL release before upgrading IBM High IOPS Adapters.

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

Syntax

```
fio-update-iodrive [options] <iodrive_version.fff>
```

where `<iodrive_version.fff>` is the path and firmware archive file provided by IBM. The default path is `C:\Program Files\IBM HIGH IOPS\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. Attention 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 -d option. Attention 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.
`-y`	Confirm all warning messages.

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

Appendix D- TRIM Support

Introduction

TRIM is used to address a unique property of solid-state devices. The problem stems from the fact that when a user deletes a file, the device that contains the file does not recognize that it can reclaim that space. Instead, the device assumes the data is valid until the system informs the device it can overwrite that data. This is fine for a normal hard device, because you can continually write to the same sector of the device without significant degradation. A solid-state device, on the other hand, writes to different flash memory areas when the same logical sector is written to.

Because of the way flash memory handles writes, having a full SSD can cause significant reduction in write throughput. Currently available storage stacks and file systems were not designed with this caveat in mind. The SSD software must assume that all sectors contain valid data, and therefore always treat the device as full. In reality, a file system does not normally contain a full device's worth of data.

TRIM is an enhancement to existing file systems that informs the SSD software of logical sectors that do not contain valid user data. TRIM retrieves this information from a file system when a file has been deleted, and it informs the device that it can reclaim the space held by that file. This allows the wear-leveling software to reclaim that space as reserve to handle future write operations.

In order for TRIM to do this, it continually runs in the background and monitors the file system(s) being used on IBM devices. The process is meant to be "lazy" so as not to noticeably impact the performance of the computer.

Platforms

The TRIM feature is available on IBM High IOPS Adapters for Windows operating systems starting with Windows Server 2003.

NOTE   TRIM capabilities have been built into Windows 7 and Windows Server 2008 R2 operating systems. IBM High IOPS Adapters support Windows 7 TRIM, which means that IBM TRIM is unnecessary under Windows Server 2008 R2, and it will not run when this operating system is present. No system changes are needed. The IBM TRIM service will automatically shut off if it detects Windows Server 2008 R2 operating system.

Using the TRIM Service

TRIM runs quietly in the background as a Windows Service a few minutes after the computer is booted, so as not to slow down the boot process. However, you can fine-tune TRIM by using the configurable settings described below.

Starting and Stopping TRIM

To start or stop the TRIM service through the Windows Services Manager,

1. Search for "Fusion-io Trim Service".

2. Click "Start service" or "Stop service".

Note that stopping the service only stops it for that session. Restarting the computer causes TRIM to run again.

Enabling TRIM

To enable the Fusion-io TRIM service,

1. Open a registry editor.

2. Navigate to

> HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\fiodrive\Parameters

3. Add the `TrimEnabled` value as a `DWORD` (see the description below).Stop the TRIM service (by either of the two previously mentioned methods) and restart it; or, restart the computer.

NOTE   The `fio-trim-config` utility will set the `TrimEnabled` flag for you and does not require a reboot of your system or a manual restart of the service for the changes to take effect. This utility is the preferred method of enabling and disabling TRIM as it prevents the user from having to edit the registry themselves which has the potential to produce undesired consequences.

TrimEnabled

This registry value controls whether TRIM will run, regardless of the user starting and stopping TRIM through either of the two previously mentioned methods. If this value is present and set to 1, then TRIM will run as normal (unless you have stopped the service using the previously mentioned methods). If this value is set to 0 before attempting to start the IBM TRIM service, the service will not run until the value is changed to 1 (or removed from the registry) and the service manually restarted. If this value is not present, TRIM assumes it should run unless you stop it. Note that this value persists across sessions, so if you restart the computer and set this value to 0, TRIM will not run when the computer starts again.

Controlling TRIM Aggressiveness

You can control how aggressive the TRIM service is. The default settings for TRIM minimize impact on computer performance while allowing the IBM High IOPS Adapter(s) to perform at their best. However, if a drive is being used with a write-intensive application, then you may want TRIM to be more aggressive. To do this, you'll need to add a few registry entries.

1. Open a registry editor.

2. Navigate to

HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\fiodrive\Parameters

3. Add the `TrimTimeDelayInSeconds` value as a `DWORD` (see the description below).

4. Add the `BitmapRetrievalDelayInMilliseconds` value as a `DWORD` (see the description below).

5. Stop the TRIM service (by either of the two previously mentioned methods) and restart it; or, restart the computer.

`TrimTimeDelayInSeconds`

This registry value controls how quickly TRIM will start running again after it has finished processing all the volumes on a system. For example, if this is set to 600 (10 minutes in seconds), then TRIM will process all the volumes on a system, sleep for 10 minutes, and then process the volumes again and continue this cycle. This value can be any number between zero and 4,294,967,295. If this value is not set or present in the registry, then TRIM assumes a default of 900 seconds (or 15 minutes).

`BitmapRetrievalDelayInMilliseconds`

This value most affects how much impact TRIM will have on the CPU. It currently defaults to 25 milliseconds but can be any number between zero (most aggressive) and 4,294,967,295 (pretty much useless).

Configurations

TRIM can be used with the following configurations and features:

- RAID volumes (mirrored, spanned, or striped). Note: RAID 5 (striped with parity) is not currently supported.

- Simple volumes (no RAID)

- Any combination of the above RAID levels across multiple devices, so long as there is at least one IBM High IOPS Adapter in the RAID set.

- Multiple partitions on the same IBM High IOPS Adapter

- NTFS and FAT32 file systems

- Volumes with mount points (no <drive letter> is defined)

- Compressed volumes

- Different cluster sizes, packet sizes, and sector sizes

- Extended and shrunk volumes

Appendix E- Monitoring the Health of ioMemory Devices

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 properly selecting NAND flash media for the hosted application and 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.

After the 0% threshold, the device will soon 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 from which you purchased the device.

NOTE For products with multiple IBM High IOPS Adapters, these modes are maintained independently for each device.

Health Monitoring Techniques

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

```
Found 1 ioDrive in this system
Fusion-io driver version: 2.2.3 build 240
Adapter: ioDrive
Fusion-io ioDrive 160GB, Product Number:FS1-002-161-ES
...
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 device is in a write-reduced state, and b) it is participating in a write-heavy workload. In this case, the device will be evicted from the RAID group. A device 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 F- Using Windows Page Files with the ioMemory Devices

Introduction

This appendix describes how to effectively use paging (swap) files on IBM High IOPS Adapters with Windows.

Using a page file with a traditional disk drive places practical limits on the usable size of the page file and virtual memory, due to the poor performance of disk drives in relation to RAM. Placing the OS paging file on one or more IBM High IOPS Adapters allows much larger page files and usable virtual memory. This is due to the much faster response times and bandwidth on IBM High IOPS Adapters versus hard disks.

Configuring Device Paging Support

The ioMemory VSL can be configured to support paging files on one or more IBM High IOPS Adapters. This requires that each IBM High IOPS Adapter used with a paging file pre-allocates the worst-case amount of memory it may need in any possible I/O scenario. This is done on a per-adapter (ioDIMM) instance.

Because of the extra host RAM memory use, paging should be enabled only on IBM High IOPS Adapters that will actually hold a paging file. It is possible to place a single paging file on more than one IBM High IOPS Adapter. In this case Windows will stripe paging I/O across all available paging files, possibly providing additional performance to the Virtual Memory (VM) subsystem.

ioMemory VSL RAM Consumption

The amount of RAM pre-allocated per IBM High IOPS Adapter depends on the device's total size and the sector (block) size selected when formatting the drive (with `fio-format`).

> NOTE Consult the *IBM ioMemory VSL Release Notes* for this version of the software for RAM usage per GB of IBM High IOPS Adapter.

Using a larger sector size significantly reduces the amount of host memory consumption needed for paging support. It is recommended that a 4K sector size be used because a) that is generally the natural size of a host memory page, and b) it minimizes overall host memory consumption. In Windows, NTFS will generally use a cluster size of 4K, so formatting to 512 is not useful except for applications that compatible only with 512-byte sector sizes (such as Windows 2003).

The indicated amount is needed per IBM High IOPS Adapter that supports paging. You must carefully plan which IBM High IOPS Adapter(s) will be used to hold a paging file.

Non-paged Memory Pool

Pre-allocated memory for the IBM High IOPS Adapter comes from the Windows kernel non-paged memory pool. This pool dynamically grows as system components consume additional kernel memory. The maximum size of this pool is restricted as follows:

- Server 2003, 2008 R1/R2 - 75% of RAM up to a maximum of 128GB.

- Vista/Windows 7 - 40% of RAM up to a maximum of 128GB.

The amount of in-use, non-paged pool memory should be noted when planning page file usage. This is because the IBM High IOPS Adapter pre-allocates RAM, and that reduces the available physical non-paged memory. The ioMemory VSL will fail to load if the total pre-allocated memory plus the in-use, non-paged memory exceeds the maximum non-paged memory pool.

To determine the total non-paged memory pool use for two IBM High IOPS Adapters, let's use the following example:

- One IBM High IOPS Adapter that requires 850 MB of RAM, and the other requires 1700 MB or RAM.
    - NOTE   Consult the *IBM ioMemory VSL Release Notes* for this version of the ioMemory VSL for RAM requirements.

- Both are formatted with a 4K sector size

- Both will support paging files

The current allocated non-paged pool is obtained from Task Manager and, in this example, has a value of 576 MiB. (Values shown in Task Manager are in MiB [1024x1024 = 1 MiB]). The total RAM on the system is 8000 MB and the OS is Server 2008 R2.

First, covert the 576 MiB into MB: `576 MiB * (1 MB/1.048576 MiB) = ~549 MB`

To calculate the total available non-paged pool, use the following formula:

`(8000 MB x 0.75) – 549 – 850 – 1700`

which still leaves 2901 MB available for the non-paged pool.

Enabling/Disabling Paging Support

Memory pre-allocation occurs during ioMemory VSL initialization. To enable paging support, you must enable the `FIO_PREALLOCATE_MEMORY` configuration item. This can be done using the `fio-config` command-line utility. This parameter is assigned a string with a list of decimal serial numbers of the IBM High IOPS Adapters that will support a paging file. The ioMemory VSL performs memory pre-allocation for those instances.

Below is an example of using the `fio-config` utility to enable paging and pre-allocation on two IBM High IOPS Adapters with serial numbers 1234 and 17834. Serial number information can be obtained using the `fio-status` utility.

```
fio-config -p FIO_PREALLOCATE_MEMORY "1234,17834"
```

To disable paging support on all devices, use a value of `0` for `FIO_PREALLOCATE_MEMORY`:

```
fio-config -p FIO_PREALLOCATE_MEMORY "0"
```

To query the current value, run this command:

```
fio-config -g FIO_PREALLOCATE_MEMORY
```

An alternate method to manage (enable or disable) paging support is to use the IBM High IOPS Management Application.

NOTE   You must reload the ioMemory VSL for the new pre-allocation setting to take effect. Typically this can be done by restarting the machine or using disable/enable within Device Manager for each IBM High IOPS Adapter instance.

Also, using the Windows System Properties to change paging file configuration requires a system restart before the properties are applied. Therefore, you can change both FIO_PREALLOCATE_MEMORY and the system page file configuration and then apply both with a single restart.

Windows Page File Management

By default, the ioMemory VSL disables support for page files. The previous section described how to enable support for page files on one or more IBM High IOPS Adapters. The following describes how to work with the built-in Windows control panels to configure and set up paging files on IBM High IOPS Adapters.

Setting Up Paging File(s)

To set up page files in Windows,

1. Go to **Control Panel** and double-click System.

2. Click **Advanced system settings** from the Task pane.

3. On the Advanced tab, click **Settings**. The Performance Options dialog opens.

4. On the Advanced tab, click **Change**. The Virtual Memory dialog opens.
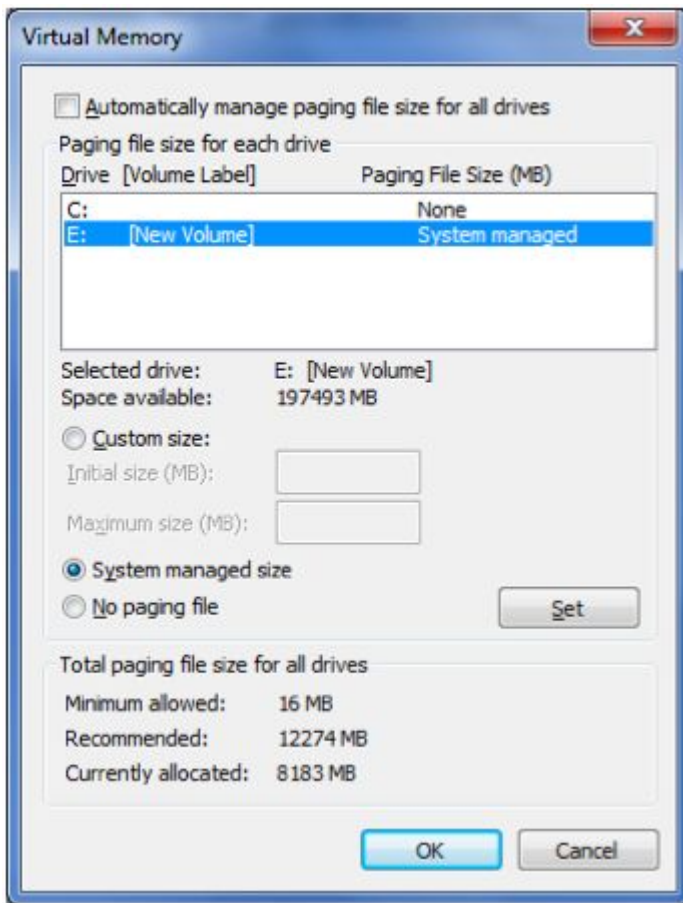
Using this dialog, you can configure a page file for each available drive in the system. Selecting the "Automatically manage paging file size for all drives" checkbox causes Windows to create a single page file on the system drive, which is the drive the OS is started from. This checkbox should be cleared when using an IBM High IOPS Adapter with a paging file.

Windows supports up to 16 distinct paging files. To enable a page file on an IBM High IOPS Adapter,

1. Choose the IBM High IOPS Adapter from the device list.

2. Select the **Custom size** radio button.

3. Provide values in the **Initial size** and **Maximum size** fields.

4. Click **Set** to save the setting. Do not omit this step, or your changes will be lost.

5. Click **OK**.

6. When prompted to restart, click **Yes**. This is necessary for the new page file settings to take effect.

To remove a paging file on the drive, follow the steps earlier but select **No paging file**. For performance reasons,

typically you will remove all paging files on any system hard disk.

> NOTE The Virtual Memory dialog allows page files to be configured on available IBM High IOPS Adapters, even if the IBM High IOPS Adapter has not been configured to support a page file. Even though the dialog allows enabling of the page file, following the required restart you'll notice that no page file was created on the device. Follow the directions earlier in this document to properly enable page file support on one or more IBM High IOPS Adapters.

System Drive Paging File Configuration

By default Windows creates and manages a page file on the system boot drive (typically a hard disk), which is typically where Windows is installed. Keeping a regular page file on the system hard disk is generally not optimal, because the hard disk's I/O performance is many orders of magnitude slower than an IBM High IOPS Adapter. To remedy this, you can eliminate or minimize the size of the system boot drive page file, as explained later. Enabling page files on IBM High IOPS Adapters (but not the system drive) improves Virtual Memory (VM) subsystem performance, as the VM manager stripes I/O across all available page files. Additionally, the IBM High IOPS Adapters act as a very large memory store, which can greatly improve memory usage for large applications.

The Windows kernel uses the system disk page file to store crash dumps. Crash dumps may be small (mini-dumps) or large (full-kernel memory dumps). Typically, running without dump file support or with a small dump file is adequate. There are several possible system drive page file configurations:

1. Eliminate all page files on any hard disks, including the system boot drive. Although this maximizes paging I/O on IBM High IOPS Adapters, no post-mortem crash dump file will be available if a system crash occurs. However, it may be possible to re-enable a page file on the system drive and then reproduce the crash scenario.

2. Create a minimal-size page file on the system boot drive. The recommended minimum size is 16MB, although Windows may warn that a minimum 400MB page file is needed.

3. Create a page file large enough for a full-kernel memory dump. This typically requires a page file at least the size of installed RAM, with some recommending the size equal to RAM x 1.5.

IBM is actively working on adding support for an IBM High IOPS Adapter being a crash dump target.

To view or change the crash dump configuration,

1. Go to the **System Properties** dialog.

2. Click the Advanced tab.

3. In the Startup and Recovery section, click **Settings**. The Startup and Recovery dialog opens.
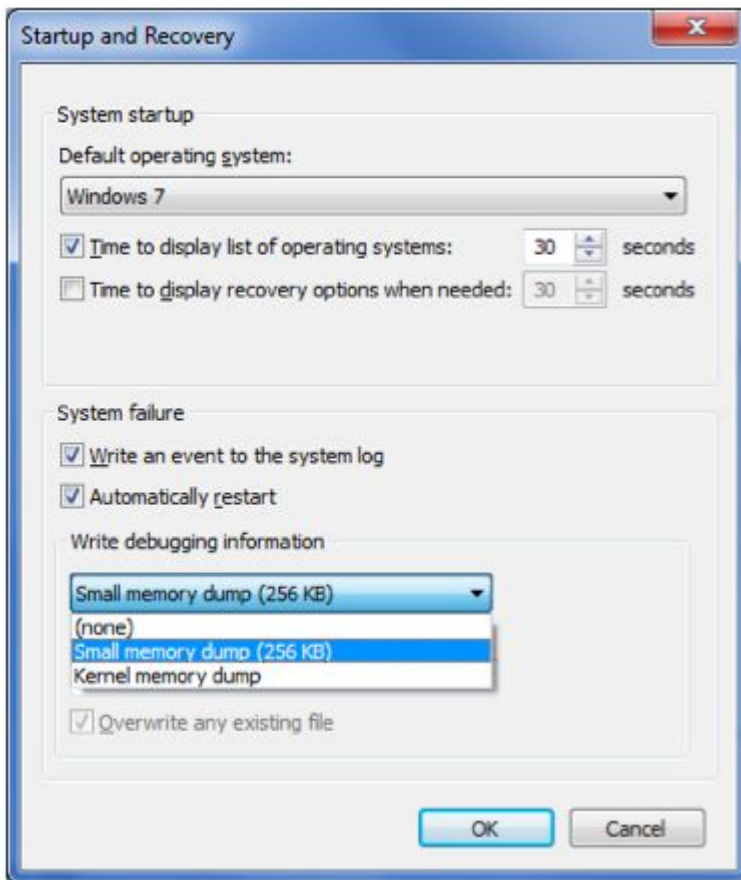
In the System Failure section you can change settings to handle the system log, restart, and debugging information.

Guaranteeing Minimum Committable Memory

If you enable "System managed size" or set a "Custom size" in the Virtual Memory dialog, you should do so with care. If the initial size is less than the desired amount of committable virtual memory, this can cause an application to have memory allocation failures if the amount of committed memory exceeds the currently allocated page file size or the initial size value. When committed memory exceeds the current page file size, a request to allocate additional memory will fail. The Windows Virtual Memory manager will slowly increase the size of the paging file up to the available size of its drive or to the "Maximum size" custom setting, whichever is smaller.

If you want to use a large amount of committed virtual memory (more than 1.5 times the amount of RAM) and avoid application memory allocation errors, the initial and maximum committed memory should be explicitly set for the expected application committed memory usage. These values should generally be the same.

How Large Should You Make the Paging File?

The following articles explain in great detail how to size the page file appropriately.

- Main Article Link: <u>Pushing the Limits of Windows</u>

- Specific section that documents virtual memory: <u>Pushing the Limits of Windows: Virtual Memory</u>

Verifying Page File Operation

To verify that a page file is actively placed on an IBM High IOPS Adapter, you can browse for hidden files at the drive's root. For example, run the following command at a prompt:

```
dir c: /ah
```

In the output listing there should be a file called `pagefile.sys`. If no page file is present, then recheck the page file configuration in the Virtual Memory dialog and verify that page file support has been enabled on the queried IBM High IOPS Adapter.

Performance

Using the IBM High IOPS Adapter as the paging store can improve overall Virtual Memory system performance. Actual benefits will vary widely with an application's virtual memory usage and with hardware platform/performance.

Appendix G- SNMP Test Mode and MIB Support

Introduction

This document explains how you can set up a test mode with your VSL Windows SNMP agent. This enables you to set test values in a Windows registry and force SNMP traps without having to create the actual conditions on the device.

For example, you can use the SNMP test mode to change the non-writeable indicator and generate a trap, or simulate a change to the physical or logical size of the device, etc.

> NOTE   To use SNMP Test Mode, you must have installed the SNMP option with your ioMemory VSL.

Using Test-Mode Registry Values

The picture below shows the registry entries included for SNMP test values.
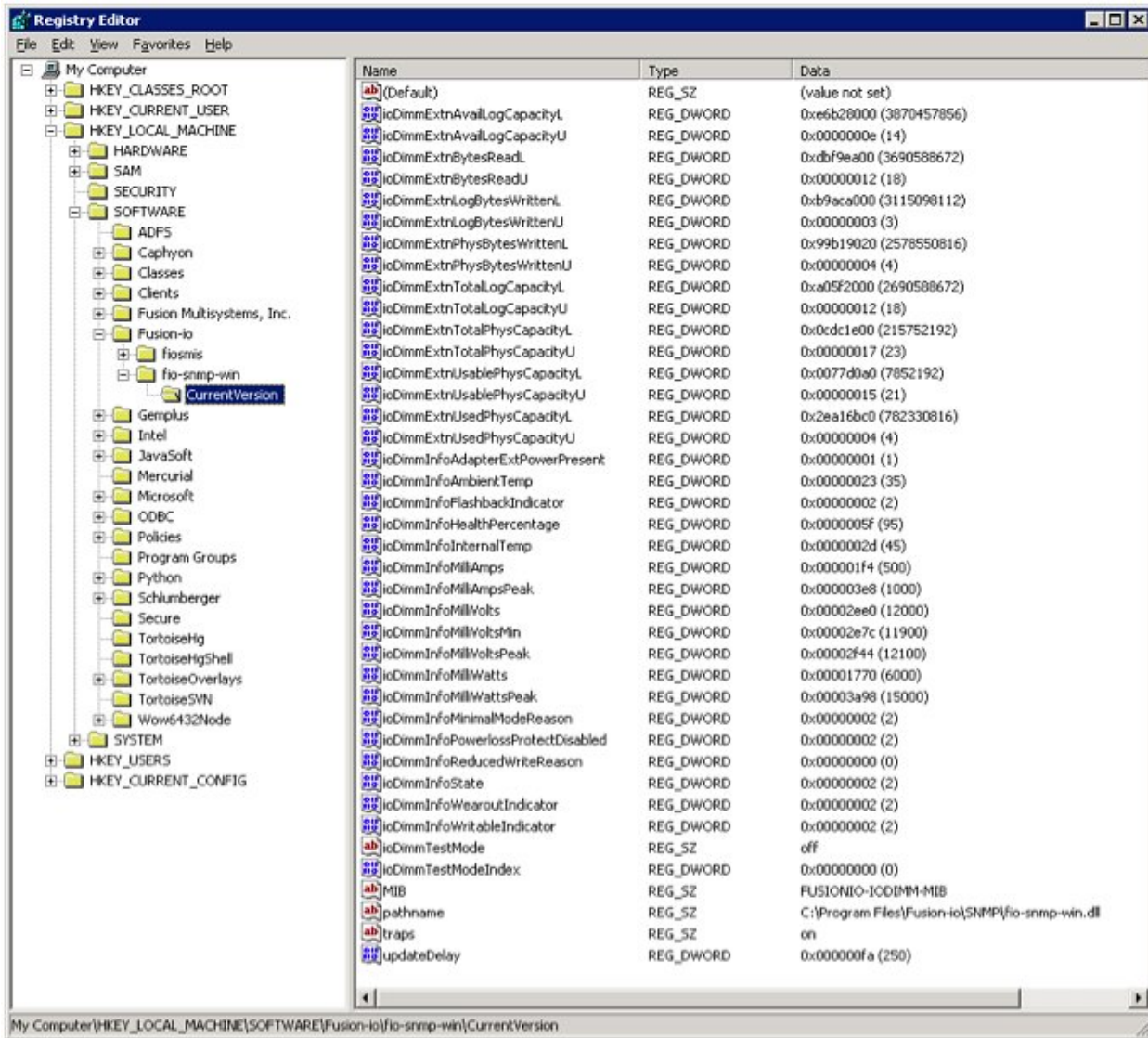
Each of these entries is described below. Entries marked by an asterisk (*) generate SNMP traps when set to the indicated values, and the `fusionIoDimmMIBCondition` and `fusionIoDimmInfoStatus MIB` variables may be affected because of the changes.

NOTE   All entries, except those marked by **, reflect your registry changes immediately. Entries marked by ** require a restart of the Windows SNMP agent for the changes to take effect.

SNMP Test Registry Entry	Description
ioDimmExtnAvailLogCapacityL	Lower word of the available logical capacity in bytes
ioDimmExtnAvailLogCapacityU	Upper word of the available logical capacity in bytes
ioDimmExtnBytesReadL	Lower word of the total number of bytes read since the device was formatted
ioDimmExtnBytesReadU	Upper word of the total number of bytes read since the device was formatted

`ioDimmExtnLogBytesWrittenL`	Lower word of the number of user data bytes written
`ioDimmExtnLogBytesWrittenU`	Upper word of the number of user data bytes written
`ioDimmExtnPhysBytesWrittenL`	Lower word of the total physical bytes written
`ioDimmExtnPhysBytesWrittenU`	Upper word of the total physical bytes written
`ioDimmExtnTotalLogCapacityL`	Lower word of the total logical capacity in bytes as formatted
`ioDimmExtnTotalLogCapacityU`	Upper word of the total logical capacity in bytes as formatted
`ioDimmExtnTotalPhysCapacityL`	Lower word of the total logical capacity in bytes as formatted
`ioDimmExtnTotalPhysCapacityU`	Upper word of the total logical capacity in bytes as formatted
`ioDimmExtnUsablePhysCapacityL`	Lower word of the useable physical capacity in bytes. This is space that is holding valid data, or is erased and ready for writing, or is waiting to be reclaimed via garbage collection.
`ioDimmExtnUsablePhysCapacityU`	Upper word of the useable physical capacity in bytes. This is space that is holding valid data, or is erased and ready for writing, or is waiting to be reclaimed via garbage collection.
`*ioDimmInfoInternalTemp`	Current internal temperature of the device in degrees Celsius. If this value is set above 78 degrees Celsius for ioDimm cards, a trap is generated. If set above 90 degrees for HP Mezzanine cards, a trap is generated.
`*ioDimmInfoFlashbackIndicator`	1 = flashback redundancy is degraded; 2 = false
`*ioDimmInfoNonWritableIndicator`	1 = device is no longer writable because it has surpassed the read-only threshold; 2 = false
`ioDimmInfoPercentLifeRemaining`	Upper word of the total logical capacity in bytes as formatted
`*ioDimmInfoState` `(trap generated if state = 4)`	Current state of the attached client device: unknown(0) detached(1) attached(2), minimal(3), error(4), detaching(5), attaching(6), scanning(7), formatting(8), updating(9), attach(10), detach(11), format(12), update(13)
`*ioDimmInfoWearoutIndicator`	Boolean: True = device has surpassed the wearout threshold
`ioDimmTestMode`	Set test mode on or off
`ioDimmTestModeIndex`	Number indicating the selected IBM

`mib`	Name of the MIB in use
`pathname`	Path to the driver, set at installation
`**traps`	Set trap generation on or off
`**updateDelay`	Number of milliseconds to wait until getting the next value from the ioMemory VSL to generate a trap

SNMP MIB Support

The following SNMP MIB fields are supported in Windows:

`fusionIoDimmMibRevMajor`	`fusionIoDimmInfoAdapterType`
`fusionIoDimmMibRevMinor`	`fusionIoDimmInfoAdapterPort`
`fusionIoDimmMIBCondition`	`fusionIoDimmInfoAdapterSerialNumber`
`fusionIoDimmInfoIndex`	`fusionIoDimmInfoAdapterExtPowerPresent`
`fusionIoDimmInfoStatus`	`fusionIoDimmInfoPowerlossProtectDisabled`
`fusionIoDimmInfoName`	`fusionIoDimmInfoInternalTempHigh`
`fusionIoDimmInfoSerialNumber`	`fusionIoDimmInfoAmbientTemp`
`fusionIoDimmInfoPartNumber`	`fusionIoDimmInfoPCIBandwidthCompatibility`
`fusionIoDimmInfoSubVendorPartNumber`	`fusionIoDimmInfoPCIPowerCompatibility`
`fusionIoDimmInfoSparePartNumber`	`fusionIoDimmInfoActualGoverningLevel`
`fusionIoDimmInfoAssemblyNumber`	`fusionIoDimmInfoLifespanGoverningLevel`
`fusionIoDimmInfoFirmwareVersion`	`fusionIoDimmInfoPowerGoverningLevel`
`fusionIoDimmInfoDriverVersion`	`fusionIoDimmInfoThermalGoverningLevel`
`fusionIoDimmInfoUID`	`fusionIoDimmInfoLifespanGoverningEnabled`
`fusionIoDimmInfoState`	`fusionIoDimmInfoLifespanGoverningTgtDate`
`fusionIoDimmInfoClientDeviceName`	`fusionIoDimmExtnIndex`
`fusionIoDimmInfoBeacon`	`fusionIoDimmExtnTotalPhysCapacityU`
`fusionIoDimmInfoPCIAddress`	`fusionIoDimmExtnTotalPhysCapacityL`
`fusionIoDimmInfoPCIDeviceID`	`fusionIoDimmExtnTotalLogCapacityU`
`fusionIoDimmInfoPCISubdeviceID`	`fusionIoDimmExtnTotalLogCapacityL`
`fusionIoDimmInfoPCIVendorID`	`fusionIoDimmExtnBytesReadU`
`fusionIoDimmInfoPCISubvendorID`	`fusionIoDimmExtnBytesReadL`

fusionIoDimmInfoPCISlot	fusionIoDimmExtnBytesWrittenU
fusionIoDimmInfoWearoutIndicator	fusionIoDimmExtnBytesWrittenL
fusionIoDimmInfoFlashbackIndicator	fusionIoDimmExtnFormattedBlockSize
fusionIoDimmInfoWritableIndicator	fusionIoDimmExtnCurrentRAMUsageU
fusionIoDimmInfoInternalTemp	fusionIoDimmExtnCurrentRAMUsageL
fusionIoDimmInfoHealthPercentage	fusionIoDimmExtnPeakRAMUsageU
fusionIoDimmInfoMinimalModeReason	fusionIoDimmExtnPeakRAMUsageL
fusionIoDimmInfoReducedWriteReason	fusionIoDimmWearoutTrap
fusionIoDimmInfoMilliVolts	fusionIoDimmNonWritableTrap
fusionIoDimmInfoMilliVoltsPeak	fusionIoDimmFlashbackTrap
fusionIoDimmInfoMilliVoltsMin	fusionIoDimmTempHighTrap
fusionIoDimmInfoMilliWatts	fusionIoDimmTempOkTrap
fusionIoDimmInfoMilliWattsPeak	fusionIoDimmErrorTrap
fusionIoDimmInfoMilliAmps	fusionIoDimmPowerlossProtectTrap
fusionIoDimmInfoMilliAmpsPeak	

Appendix H- SMI-S Interface

Attention   With ioMemory VSL 3.0.0 and later, the SMI-S provider has a new CIM namespace: `root/fio`

Introduction to the SMI-S Interface

The SMI-S interface is based on Web-Based Enterprise Management (WBEM) and provides a Common Information Model (CIM) model that represents the IBM High IOPS Adapter and associated software, in accordance with existing Distributed Management Task Force (DMTF) and Storage Networking Industry Association (SNIA) Storage Management Initiative Specification (SMI-S) standards. This model permits backward-compatible extension, accommodating new hardware and software features developed by IBM.

It is assumed that the reader is versed in WBEM, SMI-S, and DMTF standards. This document and associated model may change at any time as feedback is received.

References

CIM Schema v2.22
http://www.dmtf.org/standards/cim/cim_schema_v2220

DMTF DSP1011, Physical Asset Profile
http://www.dmtf.org/standards/published_documents/DSP1011_1.0.2.pdf

DMTF DSP1023, Software Inventory Profile
http://www.dmtf.org/standards/published_documents/DSP1023_1.0.1.pdf

DMTF DSP1033, Profile Registration Profile
http://www.dmtf.org/standards/published_documents/DSP1033_1.0.0.pdf

DMTF DSP1075 PCI Device Profile
http://www.dmtf.org/standards/published_documents/DSP1075_1.0.0.pdf

DMTF DSP1002, Diagnostics Profile
http://www.dmtf.org/standards/published_documents/DSP1002_2.0.0.pdf

SMI-S v1.4 Architecture
http://www.snia.org/tech_activities/standards/curr_standards/smi/SMI-Sv1.4_Architecture.book.pdf

SMI-S v1.4 Common Profiles
http://www.snia.org/tech_activities/standards/curr_standards/smi/SMI-Sv1.4_CommonProfiles.book.pdf

SMI-S v1.4 Host Profiles
http://www.snia.org/tech_activities/standards/curr_standards/smi/SMI-Sv1.4_Host.book.pdf

SMI-S v1.4 Common Diagnostic Model
http://www.dmtf.org/standards/mgmt/cdm/

Installing the SMI-S WMI Provider on Windows

To install the IBM SMI-S WMI provider on Windows,

1. Go to **Control Panel** > **Add & Remove Programs**.

2. Right-click **Management and Monitoring Tools** and select **Details**. Make sure the WMI Windows Installer Provider is selected.

The SMI-S WMI provider for IBM High IOPS Adapters will be installed and the WMI service will be restarted automatically.

Verifying SMI-S Installation on Windows

To verify the IBM SMI-S WMI provider on Windows,

1. Run the wbemtest.exe program. The WMI Tester window appears.
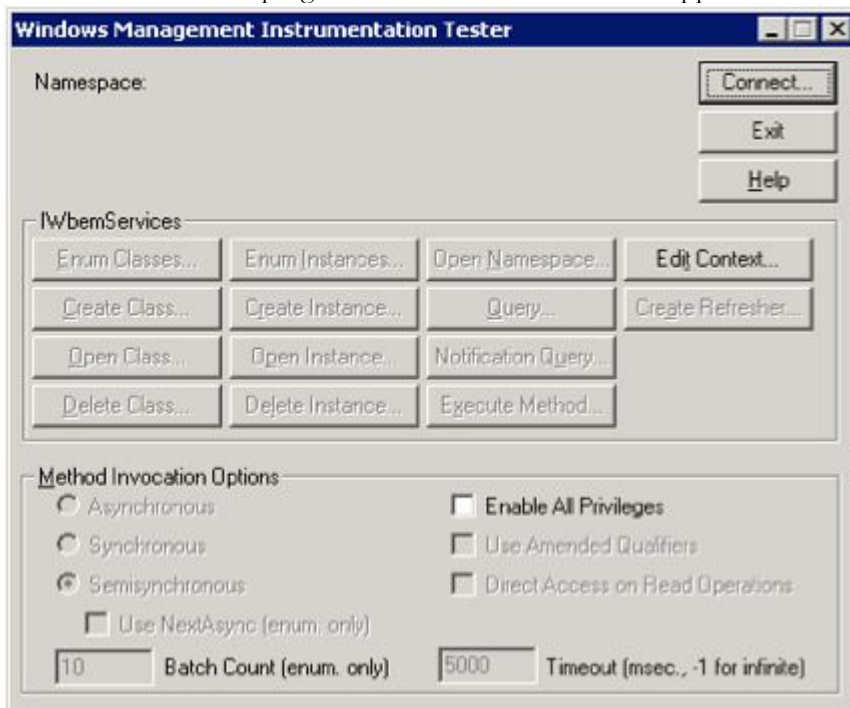
2. Click Connect to display the Connect dialog. The CIM provider namespace is `root\fio`

3. Type the namespace value shown in the screenshot above and click Connect.

The WMI Tester window appears, with the namespace value filled in.
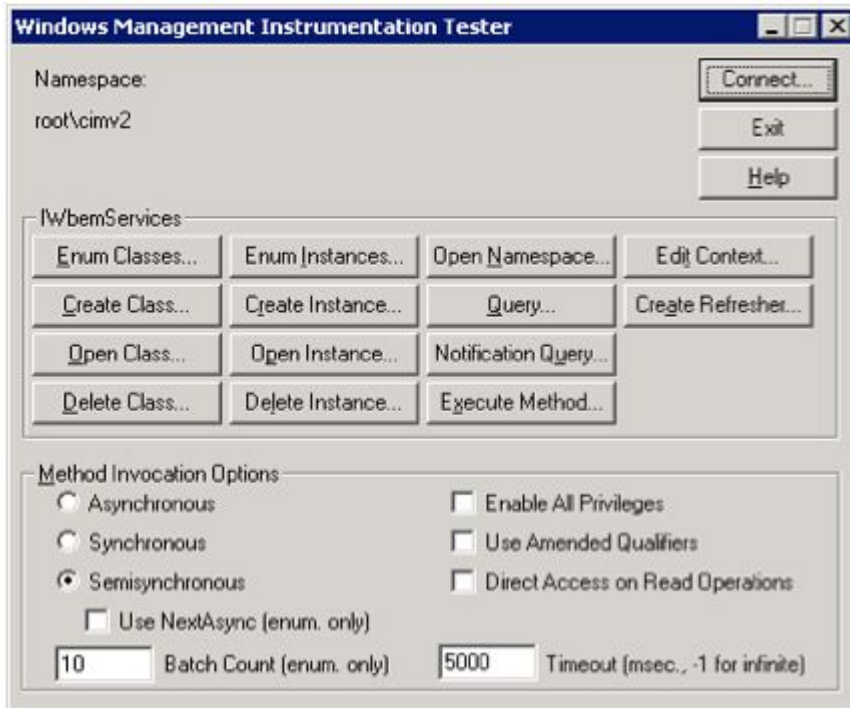
4. Click Enum Instances (second button on the first row) to bring up the Class Info dialog.
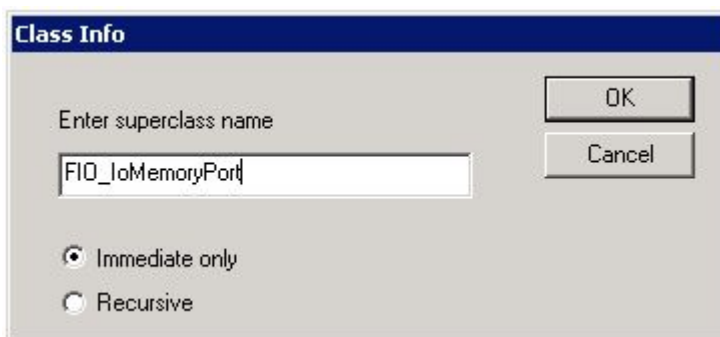
5. Type FIO_IoMemoryPort as shown above and then click OK.

If the provider is installed correctly, the result will look like the following example, with an entry for each IBM High IOPS Adapter in the system:
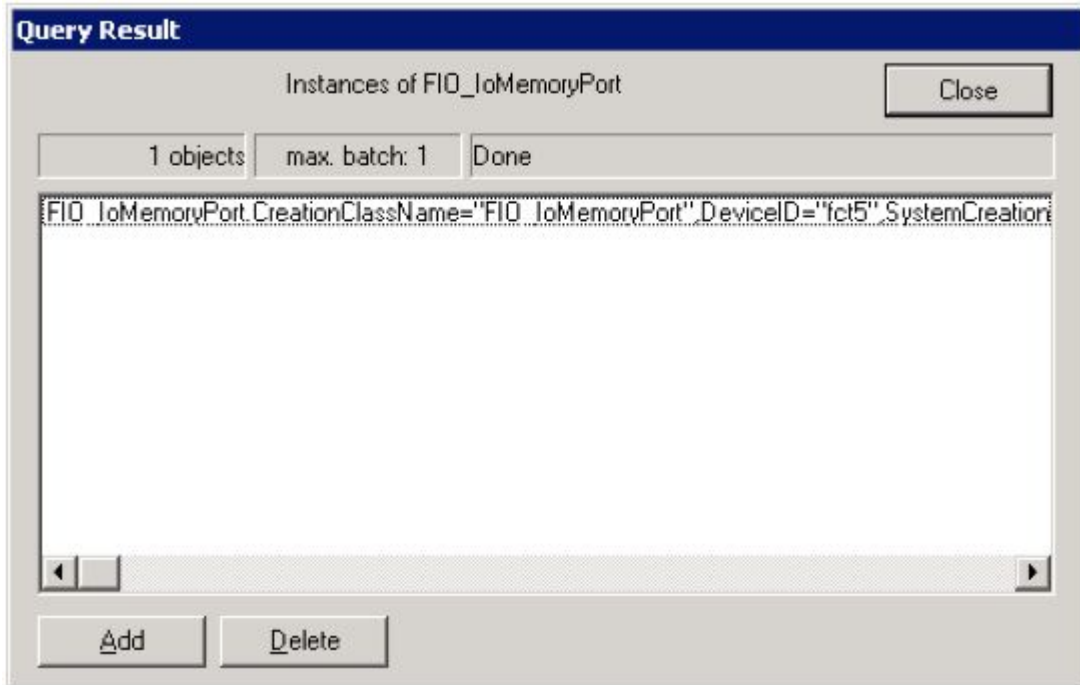
6. Double-click an entry to bring up detailed information, such as in this example:
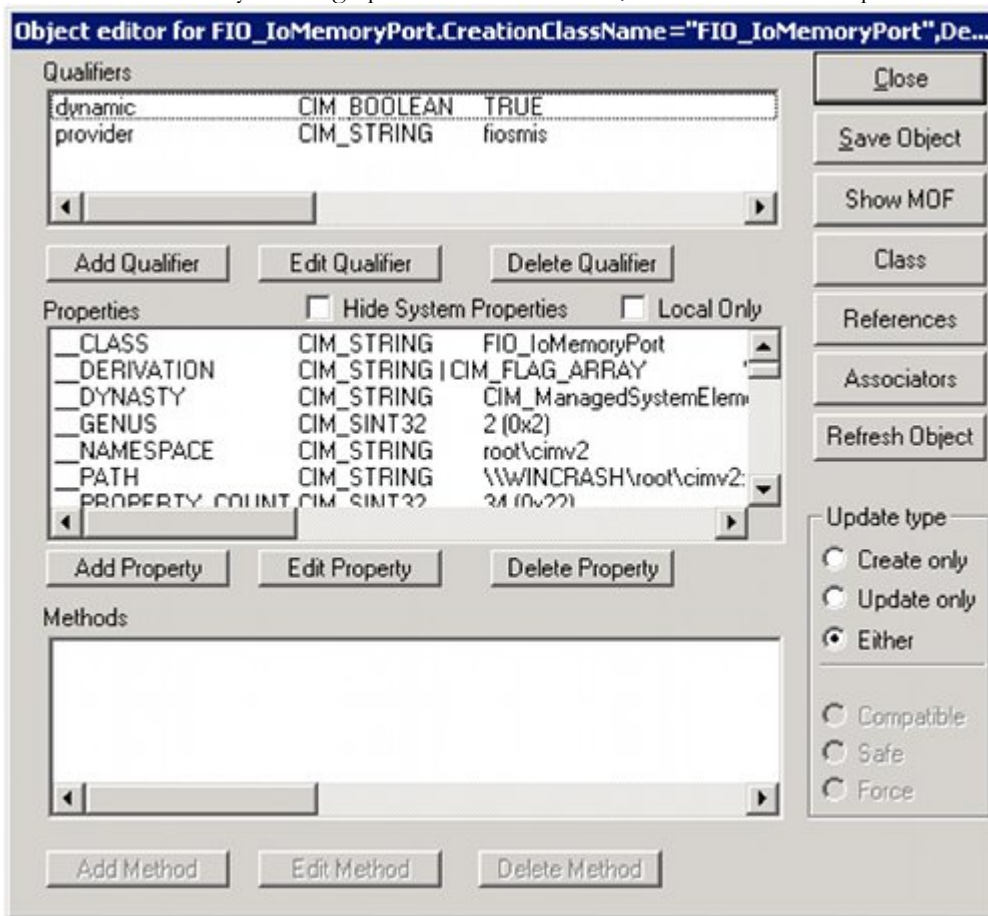
Manual Registration

If the automatic installation fails to register the provider, follow these steps to manually register it:

1. Stop the WMI (`winmgmt`) service via the services tool or the following command line:

```
net stop winmgmt
```

2. Browse to the `Fusion-io\SMIS\cim-schema` directory using the command-line interface and run the following:

```
mofcomp fio-reg-wmi.mof
```

3. Browse to `Fusion-io\SMIS\WMI` directory

4. Un-register and re-register the `fio-smis-wmi.dll` using the following commands:

```
regsvr32 /u fio-smis-wmi.dll
```

```
regsvr32 fio-smis-wmi.dll
```

5. Start the `winmgmt` service via the services toolor the following command line:

```
net start winmgmt
```

Description

SMI-S is a collection of specifications that traditionally focus on Storage Area Network (SAN) systems based on the SCSI command set, such as Fibre Channel, iSCSI, and SAS. However, the general pattern used to model these storage systems can be applied to solid-state, direct-attached storage systems such as those provided by IBM.

IBM High IOPS Adapters are modeled using the SMI-S patterns established in the Storage HBA, Direct Attached (DA) Ports, and Host Discovered Resources Profiles. The physical aspects of the IBM High IOPS Adapter and all firmware and ioMemory VSL software are modeled using published DMTF specifications, including the Physical Asset, Software Inventory, PCI Device Profiles, and Common Diagnostic Model Profile.

The following chart describes the IBM SMI-S CIM model, with IBM High IOPS Adapters and their associated firmware and software. For simplicity, the prefix FIO_ has been removed from the class names.

ComputerSystem

HostedService

D

SystemDevice

SystemPackaging

HostedAccessPoint

8

H

LogicalSSD

/dev/fioX

14

M

PhysicalPackage

6

SystemDevice

SystemDevice

3

SystemDevice

InstalledSoftwareIdentity

F

driver:
SoftwareIdentity

9

MediaPresent

J

StorageExtent

AssociatedSensor

SystemDevice

N

Realizes

13

5

ElementSoftwareIdentity

TemperatureSensor

12

InstalledSoftwareIdentity

E

IOMemoryPortController

10

SAPAvailableForElement

G

ProtocolEndpoint

K

firmware:
SoftwareIdentity

4

ControlledBy

7

DeviceSAPImplementation

11

ElementSoftwareIdentity

B

1

ConcreteIdentity

A

IOMemoryPort

/dev/fctX

2

L

PCIDevice

ElementStatisticalData

SoftwareInstallationService

ServiceAffectsElement

C

SSDStatistics

A: IOMemoryPort Class

The central instance of the model is of the `IOMemoryPort` class (A in the figure), a logical representation of the IBM High IOPS Adapter. It supports the extrinsic methods necessary to provision the drive. An instance of `PCIDevice` (B) and `IOMemoryPort` exist for each installed IBM High IOPS Adapter, and they are associated with instances of `ConcreteIdentity` (1). An instance of `SSDStatistics` (C), which contains important performance and capacity data for the device, is associated by an `ElementStatisticalData` association (2) to each `IOMemoryPort`. `IOMemoryPort` is scoped by an instance of the `ComputerSystem` class. The `SystemDevice` (3) aggregation aggregates `IOMemoryPort` within the containing `ComputerSystem`.

E: IOMemoryPortController Class

An instance of `IOMemoryPortController` (E) represents the ioMemory VSL used to control the installed IBM High IOPS Adapters. `IOMemoryPortController` specializes `CIM_PortController`, and it aggregates `IoMemoryPort` with the `ControlledBy` (4) aggregation. The software version and vendor information are represented by the `SoftwareIdentity` (F) instance that is associated to `IOMemoryPortController` (E) via `ElementSoftwareIdentity` (5). The `SoftwareIdentity` that represents the installed ioMemory VSL software is associated to the scoping `ComputerSystem` using the `InstalledSoftwareIdentity` association (6).

An instance of the `ProtocolEndpoint` class (G) represents both ends of the logical data path between the `IOMemoryPort` and the solid-state storage. This aspect of the model is derived from the pattern in the DA Ports Profile, where the port is both an initiator and target. `ProtocolEndpoint` is associated to the `IOMemoryPort` by `DeviceSAPImplementation` (7) and to the `ComputerSystem` by `HostedAccessPoint` (8).

H: LogicalSSD Class (Block Device)

The block device exposed to applications (file systems, database, and logical volume manager) is modeled using an instance of `LogicalSSD` (H), a subclass of `CIM_DiskDrive`. It is associated with a `StorageExtent` (J) using the `MediaPresent` association (9), but the `StorageExtent` will always be present. It is also associated to the `ProtocolEndpoint` (G) representing the `IOMemoryPort` using `SAPAvailableForElement` (10) and to the scoping `ComputerSystem` using `SystemDevice` (3).

IBM High IOPS Adapters, being PCIe devices, are also represented by an instance of the `PCIDevice` class (B). `IOMemoryPort` is an alternate representation of the `PCIDevice` and its associated control device. It is associated to it by the `ConcreteIdentity` association.

K: SoftwareIdentity

The ioMemory VSL software is also represented with `SoftwareIdentity`, which is associated to the `PCIDevice` by the `ElementSoftwareIdentity` association (11). The `SoftwareIdentity` (firmware) is associated to the scoping `ComputerSystem` by the `InstalledSoftwareIdentity` association (12). An instance of `SoftwareInstallationService` (L) is associated with each `PCIDevice`, which can be used to update device firmware.

M: Physical Aspects

The physical aspects of IBM High IOPS Adapters are represented by an instance of the `PhysicalPackage` class (M), which is associated to the `PCIDevice` by Realizes (13) and to the scoping `ComputerSystem` by `SystemPackaging` (14). The temperature sensors on IBM High IOPS Adapters are represented by an instance of `TemperatureSensor` (N) and is associated to the `PhysicalPackage` by `AssociatedSensor`.

Implementation

This section describes the arrangement of instances and associations for the IBM device CIM model. Not all class properties are described in detail. Consult the CIM schema for detailed description of all properties.

A WBEM CIM provider based on this model will be developed in the future. IBM intends to support popular CIMOMs, including OpenPegasus, OpenWBEM, SFCB, and Windows WMI.

The device health is indicated by the value of the `HealthLevel` property. Values include: Healthy, Warning, Reduced Write, and Read Only. These values are mapped to `standardHealthState` values – OK, Degraded/Warning, and Critical Failure – as appropriate.

Extrinsic methods for device provisioning include attach, detach, format, and update. The attach method creates a block device for the IBM High IOPS Adapter. Detach disables the block device. A format option enables users to specify the device size in either megabytes or a percentage. The update method allows users to upgrade the firmware on the device.

Device longevity is indicated by the value of the `HealthPercentage` property. `FlashbackAvailability` indicates whether or not this feature of the IBM High IOPS Adapter is online.

`IOMemoryPorts` are aggregated by `IOMemoryPortController` via the `ControlledBy` aggregation. Instances of `IOMemoryPort` are associated to their corresponding `PCIDevice` with the `ConcreteIdentity` association. The `IOMemoryPort` is a logical device of the scoping `ComputerSystem` and is indicated as such by the `SystemDevice` aggregation.

Products with two or more IBM High IOPS Adapters, such as the IBM High IOPS Duo Adapter do appear like two separate IBM High IOPS Adapters. For products with multiple devices, the `IOMemoryPort` class is extended to include information about the carrier card type, serial number, and external power connection for the product as a whole.

IOMemoryPort

One instance of `IOMemoryPort` exists for each IBM High IOPS Adapter installed in the `ComputerSystem`.

The `LocationIndicator` property reflects the state of the device indicator beacon (e.g., all LEDs on solid). Reading the value gives the current state of the indicator. Writing the value with "On" or "Off" turns the indicator on or off and can be used to determine the device's physical location.

SSDStatistics

One instance of `SSDStatistics` exists for each `IOMemoryPort` instance. Properties of this object provide performance and capacity information. Some of this information is only available when the drive is attached (i.e., the state of the associated `IOMemoryPort` is "Attached").

IOMemoryPortController

Only one instance of `IOMemoryPortContoller` exists, representing the ioMemory VSL software used to control `IOMemoryPorts`. The `IOMemoryPortController` specializes the `CIM_PortController`.

`IOMemoryPortController` is aggregated to the scoping `ComputerSystem` using the `SystemDevice` aggregation. `IOMemoryPortController` is associated with a `SoftwareInventory` instance representing the ioMemory VSL software properties via the `ElementSoftwareIdentity` association.

ProtocolEndpoint

One instance of `ProtocolEndpoint` exists for each instance of `IOMemoryPort`. It is associated to the `IOMemoryPort` using `DeviceSAPImplementation` and to `LogicalSSD` using `SAPAvailableForElement`. Because an `IOMemoryPort` represents both the initiator and target ports, only one `ProtocolEndpoint` per `IOMemoryPort` is needed to model the connection between `IOMemoryPort` and `LogicalSSD`.

LogicalSSD

One instance of `LogicalSSD`, a subclass of `CIM_DiskDrive`, exists for each block device (`/dev/fioX`) exposed by an IBM High IOPS Adapter. Correlatable IDs are used, based on operating system device names. This enables client applications to associate block devices discovered through this model with resources discovered from other SMI-S models instrumented on the host system.

ComputerSystem aggregates `LogicalSSDs` via `SystemDevice`. The `LogicalSSD` instances are associated to their

`ProtocolEndpoints` via `SAPAvailableForElement`. If the `IOMemoryPort` associated to the endpoint is not attached, then the Availability property is set to "Off Line," and the DeviceID property value is "Unknown."

StorageExtent

One instance of `StorageExtent` is associated with each `LogicalSSD` and represents the logical storage of the associated device.

SoftwareIdentity

One instance of `SoftwareIdentity` exists to represent the ioMemory VSL software. The firmware is also modeled using `SoftwareIdentity` but requires an instance for each IBM High IOPS Adapter installed. The `IsEntity` property has a value of `True`, indicating that the `SoftwareIdentity` instance corresponds to a discrete copy of the ioMemory VSL software or firmware. The `MajorVersion`, `MinorVersion`, `RevisionNumber`, and `BuildNumber` properties convey the driver/firmware version information. The `Manufacturer` property can be used to identify Fusion-io.

Another option for the firmware is to omit the `InstalledSoftwareIdentity` association with `ComputerSystem`, because the firmware is not really installed on `ComputerSystem`. This option would depend on how users want to model the firmware.

SoftwareInstallationService

An instance of `SoftwareInstallationService` exists for each `PCIDevice` and can be used to update the associated device's firmware.

PCIDevice

An instance of `PCIDevice` is instantiated for each IBM High IOPS Adapter (PCIe card) in the computer. Properties are set as follows:

- `BusNumber` – bus number where the PCIe device exists

- `DeviceNumber` – device number assigned to the PCI device for this bus.

- `FunctionNumber` – set to the function number for the PCI device.

- `SubsystemID`, `SubsystemVendorID`, `PCIDeviceID`, `VendorID`, and `RevisionID` are optional but can be populated if values can be extracted from the configuration registers of the PCI device.

`PCIDevice` is associated with `IOMemoryPort`, its alternate logical representation, using `ConcreteIdentity`. The `PCIDevice` is also associated with `PhysicalPackage`, representing the physical aspects of the IBM High IOPS Adapter, via `Realizes`.

PhysicalPackage

One instance of `PhysicalPackage` exists for each discrete, physical IBM High IOPS Adapter installed in the computer system. The `Manufacturer`, `Model`, `SKU`, `SerialNumber`, `Version`, and `PartNumber` properties can be used to describe these aspects of the physical card. `PhysicalPackage` is associated with `PCIDevice` via `Realizes` and the scoping `ComputerSystem` via `SystemPackaging`.

TemperatureSensor

One instance of `TemperatureSensor` exists for each `PhysicalPackage`. Temperature information for the drive is stored in the properties of this object.

Diagnostic Test

One instance of `DiagnosticTest` will exist. The `RunDiagnostic()` method will trigger a snapshot of device status for the specified `ManagedElement` which must be an instance of `IoMemoryPort`. The diagnostic run is synchronous and runs instantaneously. The resulting `ConcreteJob` object will associate to the originating `DiagnosticTest` instance and the respective `IoMemoryPort` instance that was specified (see Figure 2). At this time, `RunDiagnostic()` can only be used with the default `DiagnosticSettingData` provided.

Each run will add a single entry of `DiagnosticSettingDataRecord` and associated `DiagnosticCompletionRecord` in the `DiagnosticLog`. The `RecordData` property of the `DiagnosticCompletionRecord` will record critical device status at the time of the run. The format of the `RecordData` string can be found in the `RecordFormat` property.

The format is a series of status strings, each of which can hold one of the following values delimited by an asterisk (*) character: "Unknown", "OK", "Warning", or "Error". Currently, seven status values are recorded: `WearoutStatus`, `WritabilityStatus`, `FlashbackStatus`, `TemperatureStatus`, `MinimalModeStatus`, `PciStatus` and `InternalErrorStatus`. All of these should report "OK" under normal operating conditions.

WearoutStatus will be set to "Warning" when less than 10% reserve space is left on the device. It will be set to "Error" when there is no more reserved space.

- `WritabilityStatus` will be set to "Error" whenever the device is write throttling or in read-only mode. This can happen due to a variety of conditions including device wearout and insufficient power.

- `FlashbackStatus` will report "Warning" if a catastrophic error causes Flashback protection to be degraded.

- `TemperatureStatus` will report "Warning" when the device temperature is nearing the maximum safe temperature and "Error" when the maximum safe temperature is reached or surpassed.

- `MinimalModeStatus` will report either "Warning" or "Error" whenever the device is in minimal mode.

- `PciStatus` will report "Warning" or "Error" if there are compatibility problems with the host PCIe bus.

- `InternalErrorStatus` will report "Error" if there are any internal problems with the ioMemory VSL.

The `CompletionState` property will summarize the results and may be set to Unknown, OK, Warning or Failed. If any status is in error the state will report as Failed. Otherwise, if there is any warning status the state will report Warning. The Message property will be set to indicate the appropriate action if there are any warnings or errors.

DiagnosticSetting Data

There will be an instance of `DiagnosticSettingData` associated with the `DiagnosticTest` instance (see Figure 2). It records the default settings for each call to `RunDiagnostic`.

DiagnosticServiceCapabilities

There is an instance of `DiagnosticServiceCapabilities` associated with the `DiagnosticTest` instance which records the capabilities of the `DiagnosticTest` service.

DiagnosticLog

An instance of `DiagnosticLog` is associated with the `DiagnosticTest` instance and will store the results of each run.

DiagnosticSettingRecord

A copy of the default `DiagnosticSettingData` will be stored in a `DiagnosticSettingDataRecord` each time a diagnostic is run and will be associated with an instance of `DiagnosticCompletionRecord`.

DiagnosticCompletionRecord

An instance of `DiagnosticCompletionRecord` will store the results of each `RunDiagnostic` execution. The details are explained in `DiagnosticTest`.

RegisteredDiskDriveLiteProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the Disk Drive Lite Profile. The following properties are set as follows:

- `InstanceID` – set to `"SNIA:DiskDriveLiteProfile-1.4.0"`

- `RegisteredOrganization` – set to `"11"` (SNIA)

- `RegisteredName` – set to `"DirectAccess Ports Profile"`

- `RegisteredVersion` – set to `"1.4.0"`

RegisteredDAPortsProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the DA Ports Profile. The properties are set as follows:

- `InstanceID` – set to `"SNIA:DAPortsProfile-1.4.0"`

- `RegisteredOrganization` – set to `"11"` (SNIA)

- `RegisteredName` – set to `"DirectAccess Ports Profile"`

- `RegisteredVersion` – set to "1.4.0"

RegisteredStorageHBAProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the Storage HBA Profile. The properties are set as follows:

- `InstanceID` – set to "SNIA:StorageHBAProfile-1.4.0"
- `RegisteredOrganization` – set to "11" (SNIA)
- `RegisteredName` – set to "Storage HBA Profile"
- `RegisteredVersion` – set to "1.4.0"

RegisteredHostDiscoveredResourcesProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the Host Discovered Resources Profile. The properties are set as follows:

- `InstanceID` – set to "SNIA:HostDiscoveredResourcesProfile-1.2.0"
- `RegisteredOrganization` – set to "11" (SNIA)
- `RegisteredName` – set to "Host Discovered Resources Profile"
- `RegisteredVersion` – set to "1.2.0"

RegisteredPCIDeviceProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the PCI Device Profile. The properties are set as follows:

- `InstanceID` – set to "DMTF:DSP1075-PCIDevice-1.0.0a"
- `RegisteredOrganization` – set to "2" (DMTF)
- `RegisteredName` – set to "PCIDevice Profile"
- `RegisteredVersion` – set to "1.0.0a"

RegisteredSoftwareInventoryProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the Software Inventory Profile. The properties are set as follows:

- `InstanceID` – set to "DMTF:DSP1023-SoftwareInventory-1.0.1"
- `RegisteredOrganization` – set to "2" (DMTF)
- `RegisteredName` – set to "Software Inventory Profile"

- `RegisteredVersion` – set to "1.0.1"

RegisteredSoftwareUpdateProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the Software Update Profile. The properties are set as follows:

- `InstanceID` – set to "`DMTF:DSP1023-SoftwareUpdate-1.0.0`"

- `RegisteredOrganization` – set to "2" (DMTF)

- `RegisteredName` – set to "`Software Update Profile`"

- `RegisteredVersion` – set to "1.0.0"

RegisteredPhysicalAssetProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the Physical Asset Profile. The properties are set as follows:

- `InstanceID` – set to "`DMTF:PhysicalAssetProfile-1.0.2`"

- `RegisteredOrganization` – set to "2" (DMTF)

- `RegisteredName` – set to "`PhysicalAsset Profile`"

- `RegisteredVersion` – set to "1.0.2"

RegisteredSensorsProfile

Only one instance of this class is needed. It resides in the `/root/interop` namespace and indicates the implementation of the Sensors Profile. The properties are set as follows:

- `InstanceID` – set to "`SNIA:SensorsProfile-1.0.0`"

- `RegisteredOrganization` – set to "11" (SNIA)

- `RegisteredName` – set to "`Sensors Profile`"

- `RegisteredVersion` – set to "1.0.0"

RegisteredCommonDiagnosticProfile

Only one instance of this class is needed. It will reside in the `/root/interop` namespace and indicate the implementation of the Common Diagnostic Model Profile. The `InstanceID` property will be set to a value of "`DMTF:DiagnosticsProfile-2.0.0a`". The `RegisteredOrganization` property will be set to a value of "2" (DMTF). The `RegisteredName` property will be set to a value of "Diagnostics Profile". The `RegisteredVersion` property will be set to a value of "`2.0.0a`".

Indications

An indication will be generated periodically when a serious condition exists for a particular IBM High IOPS Adapter. The WBEM provider currently supports six types of indications. They alert users of the SMI-S provider to conditions such as imminent wearout, degradation of writability, degradation of the flashback feature, higher temperature, and internal error states.

The indications will be instances of the `FIO_AlertIndication` class which simply specializes the `CIM_AlertIndication` class.

The values for the properties of the `FIO_AlertIndication` instances are under development and may change as testing proceeds and feedback is received.

FIO_AlertIndication

Property	Value
IndicationIdentifier	See below for each type
IndicationTime	Timestamp when sent
AlertingManagedElement	IoMemoryPort.DeviceID=<device ID>
AlertingElementFormat	CIMObjectPath (2)
AlertType	Device Alert (5)
PerceivedSeverity	See below for each type
ProbableCause	See below for each type
SystemCreationClassName	"FIO_AlertIndication"
SystemName	<hostname>
ProviderName	"fiosmis"
CorrelatedIndications	Not used
Description	Class description
OtherAlertType	Not used
OtherSeverity	Not used
ProbableCauseDescription	Not used
EventID	Same as IndicationIdentifier
OwningEntity	<vendor>
MessageID	TBD
Message	TBD
MessageArguments	TBD

Reduced Writability Indication

The ioMemory VSL can dramatically reduce write throughput to manage device conditions such as excessive wear, high temperature, and insufficient power. The reduced writability indication is generated while the drive is in this mode. If the triggering condition is excessive wear, the IoMemoryPort health percentage will report 0% health.

Property	Value
IndicationIdentifier	<mfr>":"<hostname>":write"
PerceivedSeverity	Degraded/Warning (3)

ProbableCause	Threshold Crossed (52)
	Temperature Unacceptable (51)
	Power Problem (36)

Read-only Indication

When the drive has reached the end-of-life, it can no longer be written to and can only be read from. The read-only indication will be sent when this occurs. The `IoMemoryPort` health percentage will continue to report 0% health when this happens.

Property	Value
IndicationIdentifier	<mfr>":"<hostname>":read_only"
PerceivedSeverity	Degraded/Warning (3)
ProbableCause	Threshold Crossed (52)

Wearout Indication

As the drive wears out, this indication is generated as a warning when the drive health percentage drops below 10%, before write throughput is reduced.

Property	Value
IndicationIdentifier	<mfr>":"<hostname>":wearout"
PerceivedSeverity	Degraded/Warning (3)
ProbableCause	Threshold Crossed (52)

Flashback Indication

If a catastrophic part failure degrades the effectiveness of the flashback feature, this indication will be sent.

Property	Value
IndicationIdentifier	<mfr>":"<hostname>":flashback"
PerceivedSeverity	Degraded/Warning (3)
ProbableCause	Loss of Redundancy (88)

High Temperature Indication

This indication will be sent when the temperature of the card becomes excessive.

Property	Value
IndicationIdentifier	<mfr>":"<hostname>":temperature"
PerceivedSeverity	Critical (6)

ProbableCause	Temperature Unacceptable (51)

Error Indication

If the ioMemory VSL is in an error state the error indication will be sent.

Property	Value
IndicationIdentifier	`<mfr>":"<hostname>":error"`
PerceivedSeverity	Major (6)
ProbableCause	Other (1)

Appendix I- fio-config Options

The following table describes the ioMemory VSL parameters you can set with the `fio-config` utility.

> NOTE   `fio-config` options must be entered in uppercase to function properly.
>
> NOTE   MSI (Message Signaled Interrupts) is enabled by default for this platform, and it cannot be disabled using `fio-config`.

Option	Default (min/max)	Description
AUTO_ATTACH	True	Always attach the device on startup
IODRIVE_TINTR_HW_WAIT	0 (0, 255)	Interval (microseconds) to wait between hardware interrupts
FORCE_MINIMAL_MODE	False	Force minimal mode on the device
PARALLEL_ATTACH	False	Enable parallel attach of multiple devices.
FIO_PREALLOCATE_MEMORY	0	For the selected device, pre-allocate all memory necessary to have the drive usable as swap space. For example: ```fio-config /dev/fct0 -p FIO_PREALLOCATE_MEMORY = "1234,54321"``` where "1234" and "54321" are serial numbers obtained from `fio-status`.
WIN_DISABLE_ALL_AFFINITY	0 (affinity is enabled)	When WIN_DISABLE_ALL_AFFINITY is set to 0, the driver will enable interrupt and worker thread affinity in the driver. When WIN_DISABLE_ALL_AFFINITY is set to 1, the driver will disable all affinity settings. This is an override of any other affinity settings. The driver must be reloaded for this parameter to take effect.

`WIN_DISABLE_DEFAULT_NUMA_AFFINITY`	0 ("default" NUMA affinity is enabled)	When `WIN_DISABLE_DEFAULT_NUMA_AFFINITY` is set to `0`, during initialization, the driver will query Windows for the affinity settings assigned to the adapter by the OS. This is what is known as the "default NUMA affinity". Once the affinity is queried correctly, the driver sets the affinity of the adapter's interrupt and associated worker threads to the default OS setting. This generally has the effect of setting the affinity of the interrupt and worker threads to all processors on a single NUMA node in the system. When `WIN_DISABLE_DEFAULT_NUMA_AFFINITY` is set to `1`, the driver will ignore the affinity settings assigned to the adapter by the OS. The driver must be reloaded for this parameter to take effect.
`DriverNodeNumber<devnum>`	n/a	`DriverNodeNumber<devnum>` is used in conjunction with `SetWorkerAffinity<devnum>` to manually set the affinity of an adapter. `DriverNodeNumber<devnum>` lets you manually set the NUMA node number for the specified adapter. The adapter is specified by the `<devnum>`, which is simply the device number. The value of this parameter is an zero-based NUMA node number in the system. For example, when `DriverNodeNumber47` is set to value `2`, this will set the NUMA node of device `/dev/fct47` to node 2. <u>Attention</u> Please see the notice below about adding this parameter to the registry. The driver must be reloaded for this parameter to take effect.
`SetWorkerAffinity<devnum>`	n/a	`SetWorkerAffinity<devnum>` is used in conjunction with `DriverNodeNumber<devnum>` to manually set the affinity of an adapter. `SetWorkerAffinity<devnum>` lets you manually set the affinity bit mask of the a specified adapter. The adapter is specified by the `<devnum>`, which is simply the device number. The value of this parameter is a bit mask which represents the processors on which the adapter's interrupt and associated worker threads are to run. For example, when `SetWorkerAffinity47` is set to value `65280`, this will set the affinity of device `/dev/fct47` to bit mask `65280` (hex `0xFF00` or binary `1111111100000000`), which represents processors 8-15 on the NUMA group implied by `DriverNodeNumber47`. <u>Attention</u> Please see the notice below about adding this parameter to the registry. The driver must be reloaded for this parameter to take effect.

Attention **Adding to the Registry**: You must manually add the `SetWorkerAffinity<devnum>` and `DriverNodeNumber<devnum>` parameters to the registry with RegEdit.exe. The registry key path is: `HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\fiodrive\Parameters`. The key value type is a DWORD with key value name is either `SetWorkerAffinity<devnum>` or `DriverNodeNumber<devnum>`.

Attention For more information on configuring affinity with a NUMA system, see Appendix J- NUMA Configuration. You may need to contact Customer Support at http://www.ibm.com/systems/support for help with analyzing and configuring your system.

NOTE Other than `FIO_PREALLOCATE_MEMORY`, all `fio-config` options are global—they apply to all IBM devices in the computer.

Appendix J- NUMA Configuration

Servers with NUMA (Non-Uniform Memory Access) architecture require special installation instructions in order to maximize IBM High IOPS Adapter performance. These servers include the IBM x3850 server.

On servers with NUMA architecture, during system boot, the BIOS on some systems will not distribute PCIe slots evenly among the NUMA nodes. Each NUMA node contains multiple CPUs. This imbalanced distribution means that, during high workloads, half or more of the CPUs will remain idle while the the rest are 100% utilized. To prevent this imbalance, you must manually assign IBM High IOPS Adapters equally among the available NUMA nodes.

Attention The example below shows the final implementation of custom affinity settings. This implementation required an analysis of a specific system, including the system architecture, type and number of IBM High IOPS Adapters installed, and the particular PCIe slots that were used. Your particular circumstances will require a custom analysis of your set-up. This analysis requires understanding of your system's NUMA architecture compared to your particular installation.

Your actual settings may be different than the example below, depending on your server configuration. In order to create the correct settings for your specific system, use `fio-status` to list all of the devices (fct numbers). Next, use `fio-beacon` to identify each of the devices in their respective PCIe slots. Then use the example below of the `DL580_ioMemory_NUMA.reg` file as a template and modify it for your particular system.

Advanced Configuration Example

This sample server has 4 NUMA nodes with 8 hyper-threaded cores per node (16 logical processors per node, a total of 64 logical processors in the system). This system also uses the expansion configuration and has 11 PCIe expansion slots. During system boot, the system's BIOS will assign PCIe slots 1-6 to NUMA node 2 and PCIe slots 7-11 to NUMA node 0. NUMA nodes 1 and 3 will have no assigned PCIe slots. This creates a load balancing problem in the system when IBM High IOPS Adapters are under heavy traffic. Specifically, during these periods of high use, half of the CPUs in the system will sit idle while the other half of the CPUs are 100% utilized, thus limiting the throughput of the IBM High IOPS Adapters.

To avoid this problem, you must manually configure the affinity of the IBM High IOPS Adapters using the `SetWorkerAffinity<device_num>` and `DriverNumaNode<device_num>` configuration parameters to distribute the work load across all NUMA nodes. These parameters will override the default behavior of the ioMemory VSL driver. This is achieved by setting these parameters in the the Windows Registry. For more information about the `SetWorkerAffinity<device_num>` and `DriverNumaNode<device_num>` configuration parameters, refer to Appendix I- fio-config Options.

What follows is an example of how to manually configure 10 IBM High IOPS Duo Adapters in the previously mentioned system above. Slot 1 is a Generation 1 PCI-e slot, so it is not compatible with an IBM High IOPS Duo Adapter. Thus we can fill slots 2-11 each with an IBM High IOPS Duo Adapter. When the system boots, the default

BIOS NUMA node assignments are:

```
BIOS Assigned     PCI-e
NUMA Node         Slots      FCT device numbers
------------      -----      ----------------------------------------
0                 7-11       8,9,13,14,18,19,23,24,28,29
1                 none       none
2                 2-6        135,136,140,141,145,146,150,151,155,156
3                 none       none
```

Here, the BIOS creates a load imbalance by assigning the cards to only two NUMA nodes in the system. In order to balance the work load, we want to make the following manual settings:

```
User Assigned     PCI-e
NUMA Node         Slots      FCT device numbers
------------      -----      ----------------------------------------
0                 7-9        8,9,13,14,18,19
1                 10-11      23,24,28,29
2                 2-3        135,136,140,141
3                 4-6        145,146,150,151,155,156
```

In order to configure the ioMemory VSL driver with these override settings, use NOTEPAD to create a file named `DL580_ioMemory_NUMA.reg` with the following information:

```
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\services\fiodrive\Parameters]
"SetWorkerAffinity8"=hex(b):ff,ff,00,00,00,00,00,00
"DriverNumaNode8"=dword:00000000
"SetWorkerAffinity9"=hex(b):ff,ff,00,00,00,00,00,00
"DriverNumaNode9"=dword:00000000
"SetWorkerAffinity13"=hex(b):ff,ff,00,00,00,00,00,00
"DriverNumaNode13"=dword:00000000
"SetWorkerAffinity14"=hex(b):ff,ff,00,00,00,00,00,00
"DriverNumaNode14"=dword:00000000
"SetWorkerAffinity18"=hex(b):ff,ff,00,00,00,00,00,00
"DriverNumaNode18"=dword:00000000
"SetWorkerAffinity19"=hex(b):ff,ff,00,00,00,00,00,00
"DriverNumaNode19"=dword:00000000
"SetWorkerAffinity23"=hex(b):00,00,ff,ff,00,00,00,00
"DriverNumaNode23"=dword:00000001
"SetWorkerAffinity24"=hex(b):00,00,ff,ff,00,00,00,00
"DriverNumaNode24"=dword:00000001
"SetWorkerAffinity28"=hex(b):00,00,ff,ff,00,00,00,00
"DriverNumaNode28"=dword:00000001
"SetWorkerAffinity29"=hex(b):00,00,ff,ff,00,00,00,00
"DriverNumaNode29"=dword:00000001
"SetWorkerAffinity135"=hex(b):00,00,00,00,ff,ff,00,00
"DriverNumaNode135"=dword:00000002
"SetWorkerAffinity136"=hex(b):00,00,00,00,ff,ff,00,00
"DriverNumaNode136"=dword:00000002
"SetWorkerAffinity140"=hex(b):00,00,00,00,ff,ff,00,00
"DriverNumaNode140"=dword:00000002
"SetWorkerAffinity141"=hex(b):00,00,00,00,ff,ff,00,00
"DriverNumaNode141"=dword:00000002
"SetWorkerAffinity145"=hex(b):00,00,00,00,00,00,ff,ff
"DriverNumaNode145"=dword:00000003
"SetWorkerAffinity146"=hex(b):00,00,00,00,00,00,ff,ff
"DriverNumaNode146"=dword:00000003
"SetWorkerAffinity150"=hex(b):00,00,00,00,00,00,ff,ff
"DriverNumaNode150"=dword:00000003
"SetWorkerAffinity151"=hex(b):00,00,00,00,00,00,ff,ff
"DriverNumaNode151"=dword:00000003
"SetWorkerAffinity155"=hex(b):00,00,00,00,00,00,ff,ff
"DriverNumaNode155"=dword:00000003
"SetWorkerAffinity156"=hex(b):00,00,00,00,00,00,ff,ff
"DriverNumaNode156"=dword:00000003
```

Next, import `DL580_ioMemory_NUMA.reg` into the Windows Registry by using RegEdit. To do this, launch RegEdit.exe and select `File | Import ... | DL580_ioMemory_NUMA.reg`.

Once the parameters are imported, reboot the system.

After the system has been rebooted, check the Windows System Log to confirm that the correct NUMA node and affinity settings have been assigned to each adapter. For example, for each IBM High IOPS Adapter, there should be an entry like this:

```
fct135: Affinity for this ioMemory VSL device is set to 0x0000ffff00000000 on NUMA
node 2 in Numa group 0
```

Appendix K- 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:

AVR Bootloader

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tree.h

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IBM High IOPS Adapter software and documentation are available on the web at the following address:

http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-5083174.

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