IBM ioMemory VSL 4.1.0

User Guide for Microsoft Windows

Table of Contents

IBM ioMemory VSL 4.1.0 User Guide for Microsoft Windows

Legal Notices

Part Number: D0001566-008_1
Published: July 28, 2014

Introduction

Overview

Congratulations on your purchase of an IBM solid-state storage device. This guide explains how to install, troubleshoot, and maintain the software for your IBM io3 Flash Adapters.

NOTE-

Throughout this manual, when you see a reference to an **IBM io3 Flash Adapter**, you may substitute your particular device(s) from the *Support Devices* list located in the *IBM ioMemory VSL Release Notes*.

About the IBM io3 Flash AdapterPlatform

The IBM io3 Flash Adapter platform combines ioMemory VSL software (VSL stands for Virtual Storage Layer) with IBM io3 Flash Adapter hardware to take enterprise applications and databases to the next level.

Performance

The IBM io3 Flash Adapter platform provides consistent microsecond latency access for mixed workloads, multiple gigabytes per second access and hundreds of thousands of IOPS from a single product. The sophisticated IBM io3 Flash Adapter architecture allows for nearly symmetrical read and write performance with best-in-class low queue depth performance, making the IBM io3 Flash Adapter platform ideal across a wide variety of real world, high-performance enterprise environments.

The IBM io3 Flash Adapter platform integrates with host system CPUs as flash memory to give multiple (and mostly idle) processor cores, direct and parallel access to the flash. The platform's cut-through architecture gives systems more work per unit of processing, and continues to deliver performance increases as CPU power increases.

Endurance

The IBM io3 Flash Adapter platform offers best-in-class endurance in all capacities, which is crucial for caching and write-heavy databases and applications.

Reliability

The IBM io3 Flash Adapter platform eliminates concerns about reliability like NAND failures and excessive wear. The intelligent, self-healing feature called Adaptive Flashback provides complete, chip-level fault tolerance. Adaptive Flashback technology enables an IBM io3 Flash Adapter product to repair itself after a single chip or a multi-chip failure without interrupting business continuity.

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 io3 Flash Adapter Hardware Installation Guide* for requirements on the following:
  - PCIe Slot
  - Cooling
  - Power
- **Supported Devices**: Also see the *IBM io3 Flash Adapter Hardware Installation Guide* for a list of supported IBM io3 Flash Adapters.
- **RAM Requirements**: The *IBM ioMemory VSL Release Notes* contains memory (RAM) requirements for this version of the software.

For specific IBM io3 Flash Adapter System x server configuration information and requirements, refer to the following URL: http://www.ibm.com/support/entry/portal/docdisplay?lndocid=SERV-IO3

Supported Windows Operating Systems

- Microsoft Windows Server 2008 R2 SP1 64-Bit
- Microsoft Windows Server 2012
- Microsoft Windows Server 2012 R2
- Microsoft Hyper-V Server 2012
- Microsoft Hyper-V Server 2012 R2

NOTE-

IBM io3 Flash Adapters cannot be used as hibernation devices.

ioMemory VSL Software Installation

Installation Overview

1. Download the latest version of the software at http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-65723 (follow that link and then select **IBM High IOPS and io3 software matrix**).

2. If you have a previous version of the ioMemory VSL software installed, you must uninstall the ioMemory VSL software and the utilities. See Uninstalling the ioMemory VSL Software on page 24 for instructions. Once you have uninstalled the software, return to this page.

   Attention!

   This version of the ioMemory VSL software only supports third generation devices (such as io3 Enterprise Value Adapters and io3 Enterprise Adapters, and it does not support devices that were compatible with ioMemory VSL software version 3.x.x or earlier.

3. Install the ioMemory VSL software and command-line utilities.

4. Determine if you need to upgrade the firmware to the latest version, see See Upgrading the Firmware on page 12.

5. Configure the device(s) by following the configuration instructions, for example See Adding a Filesystem on page 14, See Creating a RAID Configuration on page 15, etc.

Installing the Software

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

2. For new device installations, make sure you have properly installed the device(s) before you install the ioMemory VSL software.

3. Log in as Administrator or have Administrator rights.

4. If needed, uninstall the existing ioMemory VSL software, utilities, etc., using **Programs and Features**, or **Add or Remove Programs** (depending on your version of Windows), in the **Control Panel**.

5. 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 software 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.
b. Restart the computer.

6. Download the ioMemory VSL installation program for Windows from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-65723 (follow that link and then select **IBM High IOPS and io3 software matrix**) to your desktop or a convenient directory.

NOTE-

Also download the `fio-firmware-highiops-<version>.<date>.fff` firmware archive file for this release and save it in the same location.

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

8. 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.

9. Click **Next**.

10. 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`

11. Follow the onscreen prompts to complete the install.

12. Choose **Finish** on the finish screen of the installer.

Attention!

You should be prompted to reboot your system to complete the installation process. If you are not prompted to reboot, you should still reboot your system after completing the installation. If Windows does not recognize the IBM io3 Flash Adapter(s) after rebooting, you may need to manually install the ioMemory VSL software for the device(s). See Manual Installation on page 51 for information on manual installation.

NOTE-

Pagefile Support

If your IBM io3 Flash Adapter is configured for pagefile support (see See Using the Device as a Page Files Store on page 15 for mor information), you may need to reboot a second time before Windows can create a permanent pagefile.

NOTE-

You may also install the IBM Flash Management Console (optional GUI management software). IBM Flash Management Console and documentation are available as a separate download.

NOTE-

IBM io3 Flash Adapters cannot be used as hibernation devices.

Once the system restarts, proceed to See Upgrading the Firmware on page 12.

Silent Install Option

Attention!

Uninstall Previous

If the you have a version of the ioMemory VSL software 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 software using its default settings, eliminating the need to "click Next" or select settings during install.

Attention!

Be sure to use the `/quiet` parameter. The command-line quiet install parameter has changed and the installer no longer supports the abbreviated parameter (`/qn`). If you pass the `/qn` parameter to the installer, the installer will ignore the parameter and the installer GUI will launch.

Silent Uninstall

You may silently uninstall the ioMemory VSL software with this command:

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

Upgrading the Firmware

With the ioMemory VSL software loaded, you need to check to ensure that the IBM io3 Flash Adapter's firmware is up-to-date and then update the firmware if needed. You can do this with the command-line utilities.

NOTE-

Make sure you have downloaded the firmware archive file that goes with this version of the ioMemory VSL software.

Attention!

Do not attempt to downgrade the firmware on any IBM io3 Flash Adapter, doing so may void your warranty.

Attention!

When installing a new IBM io3 Flash 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 software before installing the new devices. Consult the *IBM ioMemory VSL Release Notes* for this ioMemory VSL software release for any upgrade considerations.

Attention!

Upgrading Guest OS

If you are using your IBM io3 Flash Adapter within a guest OS (for example, using VMDirectPathIO), you must power cycle the host server after you upgrade the device(s). Just restarting the virtual machine will not apply the the firmware update.

More information on these command-line utilities is available in See Command-line Utilities Reference on page 30. All command-line utilities require Administrator rights . Follow these steps to upgrade the firmware:

1. Run the `fio-status` utility and examine the output. See See fio-status on page 40 for usage information.
    - If any device is in minimal mode and the reason is outdated firmware then you must update the firmware.
    - If the a device is not in minimal mode, but the firmware listed for that device is a lower number than the latest firmware version available with this version of the ioMemory VSL software, then the firmware is old, but not outdated.
2. If the firmware is old or outdated, update it using the `fio-update-iodrive` utility. See See fio-update-iodrive on page 45 for complete information and warnings.

Configuration

Once you have your IBM io3 Flash Adapter and ioMemory VSL software installed and loaded, and the firmware on the device is current, you may need to configure the device and/or software. This section outlines some of the common configurations that you may need to consider.

Setting the ioMemory VSL Options

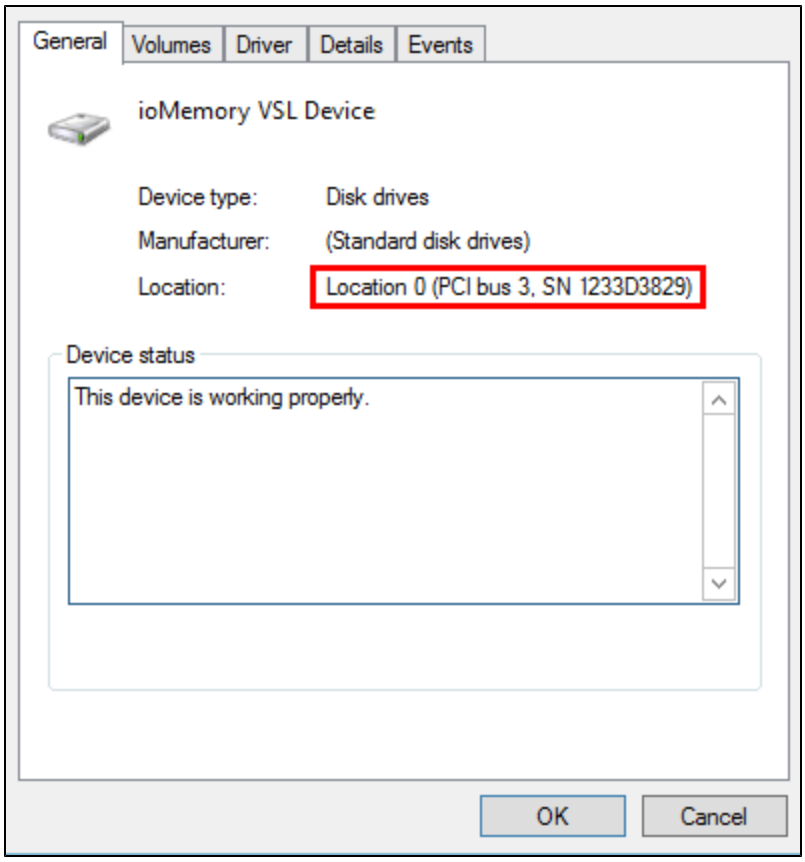
You can configure the ioMemory VSL software using various module parameters. Individual module parameters are described throughout this guide. For a complete list of all parameters and how to implement them see See fio-config on page 33.

Device Naming

The IBM io3 Flash Adapter receives a name and number as part of the install process for identification. The syntax is `fctx` where *x* indicates the device number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM io3 Flash Adapter installed on the system. Use the IBM Flash Management Console or the `fio-status` utility to view this bus number, or follow these steps:

1. Choose **Start** > **Control Panel** > **System** > **Hardware** > **Device Manager**.
2. Select **Disk Drives**.

3. Click on your IBM io3 Flash Adapter in the list. The Properties dialog box appears.



The Location field shows the PCIe bus number for your device.

Adding a Filesystem

With IBM io3 Flash Adapter(s) and ioMemory VSL software 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 io3 Flash 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 io3 Flash 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 io3 Flash Adapter in the list of storage devices on the right. (If the

IBM io3 Flash 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 io3 Flash Adapter in the list.)

6. Click **Initialize Disk**.

You can now use the Disk Management Utility to add a file system to your IBM io3 Flash Adapter.

Creating a RAID Configuration

You can use your IBM io3 Flash Adapter as part of a RAID configuration with one or more additional IBM io3 Flash Adapters. To do so, you must format your IBM io3 Flash Adapters as dynamic volumes. In turn, you can then use these dynamic volumes to create multi-disk RAID configurations (spanned, striped, or mirrored).

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 a Page Files Store

To safely use the IBM io3 Flash Adapter with page files (also known as Virtual Memory) requires passing the preallocate_memory kernel module parameter. To set this parameter, use the fio-config command-line utility (see See fio-config on page 33 for the full utility instructions):

```
fio-config -p FIO_PREALLOCATE_MEMORY 1149D2717-1121,1149D2717-1111,10345
```

- Where `1149D2717-1111,1149D2717-1111,10345` are serial numbers obtained from `fio-status`, see See fio-format on page 38.

A 4K sector size format is required for swap—this reduces the ioMemory VSL software memory footprint. Use `fio-format` to format the IBM io3 Flash Adapter with 4K sector sizes.

Once you have set this parameter, you can go into the system settings and use the IBM io3 Flash Adapter(s) to store the paging files. For more information see See Using the Windows Page Files on page 56.

Attention!

You must have enough RAM available to enable the IBM io3 Flash Adapter with pre-allocation enabled for use as swap. Attaching an IBM io3 Flash Adapter, with pre-allocation enabled, without sufficient RAM may result in the loss of user processes and system instability.

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

NOTE-

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

Discard (TRIM) Support

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

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

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

Attention!

Windows does not support TRIM with a RAID 5 configuration.

TRIM on Windows Server 2008 R2 and Newer

Windows Server 2008 R2 and newer have built-in TRIM support. With these operating systems, ioMemory devices work with Windows TRIM commands by default.

Performance and Tuning

IBM io3 Flash Adapters provide high bandwidth, high Input/Output per Second (IOPS), and are specifically designed to achieve low latency.

As IBM io3 Flash Adapters improve 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 io3 Flash Adapters.

While IBM io3 Flash Adapters generally perform well out of the box, this section describes some of the common areas where tuning may help achieve optimal performance.

Disable CPU Frequency Scaling

Dynamic Voltage and Frequency Scaling (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 IOPS. When tuning for performance, you may benefit from reducing or disabling DVFS completely, even though this may increase power consumption.

DVFS, if available, is often 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 ACPI 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 can 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.

Setting ACPI C-State Options

If your processor has ACPI C-states available, you can typically limit or 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 may require special installation instructions in order to maximize IBM io3 Flash Adapter performance. This includes most multi-socket servers.

On some servers with NUMA architecture, during system boot, the BIOS will not associate PCIe slots with the correct NUMA node. Incorrect mappings result in inefficient I/O handling that can significantly degrade performance. To prevent this, you must manually assign ioMemory devices optimally among the available NUMA nodes.

See See NUMA Configuration on page 63 for more information on parameters for setting this affinity.

Setting the Interrupt Handler Affinity

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

Many operating systems will attempt to dynamically place interrupts across the nodes, and generally make good decisions.

Windows IRQ Policy

By default, Windows uses a policy of `IrqPolicyAllCloseProcessors` and a priority of IrqPriorityNormal, which should work best for most applications.

If manual tuning is needed, Windows provides the Interrupt Affinity Policy Tool. Information on this tool can be found at: http://msdn.microsoft.com/en-us/windows/hardware/gg463378. The settings that the application changes are listed at: http://msdn.microsoft.com/en-us/library/ff547969(v=vs.85).aspx.

With Windows Sever 2008 or newer on a machine with more than 64 processors, there's an additional GroupPolicy parameter that can be set through the registry in order to set the affinity to a different processor group. This is documented at: http://msdn.microsoft.com/en-us/windows/hardware/gg463349.

Monitoring and Managing Devices

IBM provides many tools for managing your IBM io3 Flash Adapters. These tools will allow you to monitor the devices for errors, warnings, and potential problems. They will also allow you to manage the devices including performing the following functions:

- Firmware upgrades
- Low-level formatting
- Attach and detach actions
- Device status and performance information
- Configuring Swap and Paging
- Generating bug reports

Management Tools

IBM has provided several tools for monitoring and managing IBM io3 Flash Adapters. These include stand-alone tools that require no additional software and data-source tools that can be integrated with other applications.

Consider the descriptions of each tool to decide which tool (or combination of tools) best fits your needs.

Attention!

The ioMemory VSL software does print some error messages to the system logs, and while these messages are very useful for troubleshooting purposes, the ioMemory VSL software log messages are not designed for continual monitoring purposes (as each is based on a variety of factors that could produce different log messages depending on environment and use case). For best results, use the tools described in this section to regularly monitor your devices.

Stand-alone Tools

- **Command-line Utilities**: These utilities are installed with the ioMemory VSL software and are run manually in a terminal. The `fio-status` utility provides status for all devices within a host. The other utilities allow you to perform other management functions. See See Command-line Utilities Reference on page 30 for full details.

Data-source Tools

These data-source tools provide comprehensive data, just like the stand-alone tools, but they do require integration with additional software. At a minimum, some tools can interface with a browser. ***However, the benefit of these tools is that they can be integrated into existing management software that is customized for your organization.***

These tool packages and documentation are also available as separate downloads (separate from the ioMemory VSL software packages).

- **SNMP Subagent**: The IBM SNMP AgentX subagent allows you to monitor and manage your IBM io3 Flash Adapters using the Simple Network Management Protocol. You can use a normal SNMP browser, or customize your existing application to interface with the subagent.
- **SMI-S CIM Provider**: The CIM provider allows you to monitor and manage your devices using the Common Information Model. You can use a normal CIM browser, or customize your existing application to interface with the CIM provider.
- **ioMemory VSL Management SDK**: This C programing API allows you to write customize applications for monitoring and managing IBM io3 Flash Adapters.

Example Conditions to Monitor

This section gives examples of conditions you can monitor. It is intended as an introduction and not as a comprehensive reference. These conditions will have slightly different names, states, and values, depending on the tool you choose. For example, an SNMP MIB may have a different name than a SMI-S object or an API function.

In order to properly monitor these conditions, you should become familiar with the tool you choose to implement and read the documentation for that tool. You may also discover additional conditions that you wish to frequently monitor.

For quick reference, the possible states/values of these conditions are described as Normal (**GREEN**), Caution/Alert (**YELLOW**), or Error/Warning (**RED**). You may implement your own ranges of acceptable states/values, especially if you use a data-source tool.

Device Status

All of the monitoring tools return information on the status of the IBM io3 Flash Adapters, including the following states:

GREEN	Attached
YELLOW	Detached, Busy (including: Detaching, Attaching, Scanning, Formatting, and Updating)
RED	Minimal Mode, Powerloss Protect Disabled

If the device is in Minimal Mode, the monitoring tool can display the reason for the Minimal Mode status.

Required Actions

If the device is in Minimal Mode, the action will depend on the reason. For example, if the reason is outdated firmware, then you will need to update the firmware.

Temperature

IBM io3 Flash Adapters require adequate cooling. In order to prevent thermal damage, the ioMemory VSL software will start throttling write performance once the on-board controller reaches a specified temperature. If the controller temperature continues to rise, the software will shut down the device once the controller temperature reaches the maximum operating temperature.

These temperatures depend on the device. Newer IBM io3 Flash Adapters have higher thermal tolerances. Consult the *IBM io3 Flash Adapter Hardware Installation Guide* to determine the thermal tolerances of all

devices you will monitor. **This table uses the controller thermal tolerances for newer devices** (79°C throttling, 85°C shutdown).

GREEN	<79°C
YELLOW	79-84°C
RED	85°C

You may wish to shift the conditions by a few degrees so the **YELLOW** condition exists before throttling occurs. For example:

GREEN	<75°C
YELLOW	75-83°C
RED	83°C

Attention!

NAND Temperature

IBM io3 Flash Adapters also report the temperature of the NAND. This is also a critical temperature to monitor. Consult the *IBM io3 Flash Adapter Hardware Installation Guide* to see if your device reports this temperature and to see the temperature thresholds.

Required Actions

If the temperature is at or approaching the **YELLOW** condition, thermal mitigation steps may be necessary. Evaluate the server environment and system requirements necessary to operate the IBM io3 Flash Adapters. Server operating conditions are documented in the user guides for the server and the requirement to operate IBM io3 Flash Adapters is at the following website, which may include updates to uEFI and IMM code levels:

http://www.ibm.com/support/entry/portal/docdisplay?lndocid=SERV-IO3

Health Reserves Percentage

IBM io3 Flash Adapters are highly fault-tolerant storage subsystem with 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 pro-actively monitoring device age and health, you can ensure reliable performance over the intended product life. The following table describes the Health Reserve conditions.

GREEN	>10%
YELLOW	0-10%
RED	0%

At the 10% healthy threshold, a one-time warning is issued. At 0%, the device is considered unhealthy. It enters *write-reduced* mode. After the 0% threshold, the device will soon enter *read-only* mode.

For complete information on Health Reserve conditions and their impact on performance, see See Monitoring the Health of Devices on page 54.

Required Actions

The device needs close monitoring as it approaches 0% reserves and goes into write-reduced mode, which will result in reduced write performance. Prepare to replace the device soon.

Write (Health Reserves) Status

In correlation with the Health Reserves Percentage, the management tools will return write states similar to these:

GREEN	Device is healthy
YELLOW	Device is getting close to entering reduced write mode.
RED	Device has entered reduced-write or read-only mode to preserve the flash from further wearout.

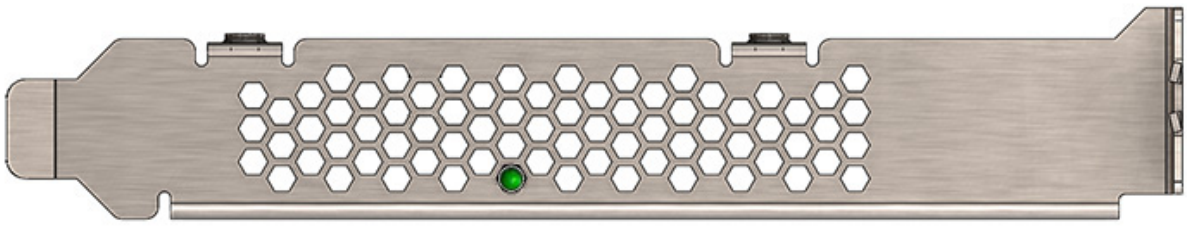
Required Actions

The device needs close monitoring as it approaches 0% reserves and goes into write-reduced mode, which will result in reduced write performance. Prepare to replace the device soon.

Device LED Indicator

If you have physical access to the devices and depending on your device configuration, you can use the LED indicator on the bracket to monitor their status.

If your device has one LED, it should be similar to this configuration:



This table explains the information that the LED conveys:

LED	Indications	Notes
LIT	Power is on and driver is working.	

FLASHING (Fast)	Read and/or write activity.	The faster flashing only indicates activity, it does not reflect the amount of data that is read or written. The flashing may not indicate reads from empty sectors (all zeros).
FLASHING (Slow)	Location beacon.	Use the `fio-beacon` utility to initiate this behavior.
OFF	This indicates one of the following: Power is off, driver is not loaded, or driver is not working.	Check `fio-status` to see if device is attached and there are no errors.

Maintenance

This section explains additional software maintenance functions not covered in the sections See Configuration on page 13 and See Monitoring and Managing Devices on page 19.

Uninstalling the ioMemory VSL Software

Attention!

This version of the ioMemory VSL software only supports third generation devices (such as io3 Enterprise Value Adapters), and it does not support devices that were compatible with ioMemory VSL software version 3.x.x or earlier.

Attention!

You must uninstall all previous versions of the ioMemory VSL software before you install the lastest version.

To uninstall the ioMemory VSL software,

1. Go to **Start** > **Control Panel**.
2. Click **Programs & Features**.
3. Select the **ioMemory VSL** entry.
4. Click **Uninstall**.

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

Attention!

The ioMemory VSL software utilities are **not** uninstalled with this procedure. If you are upgrading to a newer version of the ioMemory VSL software, you do not need to manually uninstall these utilities. However, if you are uninstalling the software completely, or planning on installing an earlier version of the ioMemory VSL software you should manually remove the following folder and its contents: `C:\Program Files\IBM HIGH IOPS`.

Defragmentation

The IBM io3 Flash Adapter does not need to be defragmented. Some versions of Windows, however, run defragmentation as a scheduled task automatically. You should turn off automatic defragmentation.

Disabling Auto-Attach

When the ioMemory VSL software is installed, it is configured to automatically attach any devices when the ioMemory VSL software is loaded. Sometimes you may want to disable the auto-attach feature (to assist in

troubleshooting or diagnostics). To do so:

1. Open the command-line interface with Administrator permissions.
2. Run the following command:

```
fio-config -p AUTO_ATTACH 0
```

   a. See See fio-config on page 33 for more information on setting parameters.

Once you restart your system, your IBM io3 Flash Adapter will no longer automatically attach until you re-enable auto attach (see See Enabling Auto-Attach on page 25)

When you finish troubleshooting the ioMemory VSL software issue, use the `fio-attach` utility to attach the IBM io3 Flash Adapter(s) and make them available to Windows.

Enabling Auto-Attach

To re-enable auto-attach after disabling it using the method described in [Disabling Auto-Attach]:

1. Open the command-line interface with Administrator permissions.
2. a. Run the following command:

```
fio-config -p AUTO_ATTACH 1
```

   i. See See fio-config on page 33 for more information on setting parameters.

The next time you restart your Windows system, your IBM io3 Flash Adapter will automatically attach.

Unmanaged Shutdown Issues

Unmanaged shutdown due to power loss or other circumstances can force the IBM io3 Flash 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 io3 Flash Adapter(s) will remain unavailable to users until the check is done. (You can perform this check later on using IBM Flash Management Console's Attach function).

Although data written to the IBM io3 Flash Adapter will not be lost due to unmanaged shutdowns, important data structures may not have been properly committed to the device. This consistency check (also called a rescan) repairs these data structures.

Improving Rescan Times

The rescan of the device (also called a consistency check) the ioMemory VSL software performs after an unmanaged shutdown may take an extended period of time depending on the total capacity of the device(s) that the ioMemory VSL software needs to scan.

Default Fast Rescan

By default, all IBM io3 Flash Adapters formatted with the fio-format utility are formatted to have improved rescan times. You can disable this default fast rescan by reformatting the device and using the `-R` option. Disabling this feature will reclaim some reserve capacity that is normally set aside to help improve rescan times.

If you leave the default fast rescan feature in place you can also take further steps to improve rescan times by implementing one of the following module parameters.

Faster Rescans Using Module Parameters

These two module parameters require the default fast rescan formatting structure, and they also use system memory (RAM) to help improve rescan times. The extra memory enables the rescan process to complete faster, which reduces downtime after a hard shutdown. This memory allocation is only temporary and is freed up after the rescan process is complete.

If you decide to use one of these parameters, you will need to set the upper limit of RAM used by that parameter. To do this, you will need to determine how much RAM each parameter may use in your scenario, how much system RAM is available, and (therefore) which parameter is more suited for your use case.

For more information on setting module parameters, see See fio-config on page 33.

Here is a quick comparison of the two parameters:

- **RMAP Parameter**
  - **Fastest**: This improvement results in the fastest rescan times.
  - **Less Scalable**: (All or nothing.) This parameter requires enough RAM to function. If the RAM limit is set too low, then the ioMemory VSL software will not use RMAP at all, and it will revert back to the default fast rescan process.
  - **Target Scenario**: This parameter will improve any use case if there is enough RAM available for the parameter. It is more suited for smaller capacity IBM io3 Flash Adapters and/or systems with fewer IBM io3 Flash Adapters installed. We also recommend it for devices that have been used for many small random writes.
- **RSORT Parameter**
  - **Faster**: This improves rescan times over the default fast rescan process.
  - **Scalable**: With this parameter, the ioMemory VSL softwareworks with the system RAM to improve rescan times until it reaches the RAM limit set in the parameter. At that point, the software reverts back to the default fast rescan process.

- **Target Scenario**: This parameter will improve rescan times in any use scenario. It is especially useful in systems with multiple IBM io3 Flash Adapters and/or larger-capacity IBM io3 Flash Adapters. We also recommend it when IBM io3 Flash Adapters are used to store databases.

RMAP Parameter

The RMAP_MEMORY_LIMIT_MiB parameter sets the upper memory (RAM) limit (in mebibytes) used by the ioMemory VSL software to perform the RMAP rescan process. You should only use this option if you have enough memory for all of your IBM io3 Flash Adapters in the system. If you do not have enough memory to use this option, use the RSORT parameter instead.

Because this parameter requires a set amount of memory, it often works best with fewer IBM io3 Flash Adapters and/or smaller-capacity IBM io3 Flash Adapters in a system, but the determining factor is how much memory is in the system and whether there is enough to set the appropriate memory limit.

This parameter requires `4.008` bytes of RAM per block of IBM io3 Flash Adapter capacity.

1. First determine the number of blocks that are formatted for each device.

   a. This information is visible when you format the device using the `fio-format` utility.

   b. Or you can estimate the number of blocks using the device capacity and the formatted sector size.

      This example shows a quick estimation of the number of blocks on a `1000GB` device with `512B` size sectors (`2` blocks per KB):

      ```
      1000GB * 1000MB/GB * 1000KB/MB * 1000B/KB * 1 Block/512B = 1,
      953,125,000 Blocks
      ```

2. Multiply the number of blocks by `4.008` bytes of RAM per block (and translate that into MiB) to determine the memory limit that is required for this parameter to function.

   a. In the example above there were about `1.95 billion` blocks:

      ```
      1,953,125,000 Blocks * 4.008B/Block * 1KiB/1024B * 1MiB/1024KiB
      = ~74656MiB of RAM
      ```

   b. In this example, you would need about 7465 MiB of RAM available in your system for a 1000GB IBM io3 Flash Adapter formatted for 512B sectors, and you would need to set the RMAP parameter to `7500`.

NOTE-

Default Value

The RMAP parameter is, by default, set to `3100`. It is set to this low default value so the rescan process does not use all of the RAM in systems that have less available memory.

- If the RMAP value is too low for the number of IBM io3 Flash Adapter blocks in the system, then the ioMemory VSL software will not use the RMAP process to improve rescan times, it will just use the default fast rescan process. (RMAP is an all-or-nothing setting.)

- If you don't have enough system memory to use the RMAP parameter, consider using the RSORT parameter. The RSORT parameter will use its RAM limit to improve the rescan process, and then the ioMemory VSL softwarerevert to the default fast rescan process to finish the consistency check.

3. Set the module parameter to the value you have determined. See See fio-config on page 33 for more information on setting parameters.

RSORT Parameter

The RSORT_MEMORY_LIMIT_MiB parameter sets the memory (RAM) limit used by the ioMemory VSL software to perform the RSORT rescan process. The RSORT rescan process is faster than the default rescan process and we recommend using it to rescan devices that are used datastores for databases.

If this parameter is given any memory limit, the ioMemory VSL software will use the RSORT process until either the rescan is done or it consumes the memory limit. If the process runs out of memory, it will revert to the default fast rescan process. However, in order to optimize the use of this process, you can calculate the target RAM usage and set the limit based on that target. There is no penalty for setting a high limit, the RSORT process will only use the RAM it needs (up to the limit that is set).

This target is based on `32` bytes per write extent. For example, if your database writes 16KB at a time, there is one write extent per 16KB of IBM io3 Flash Adapter capacity.

NOTE-

Blocks per Write Extent

One measure of the the benefits of the RSORT process is to see how many blocks are written per write extent. The RSORT process improves rescan times over the default fast rescan process on when a device has `8` or more blocks written per extent. For example, if your IBM io3 Flash Adapter is formatted to `512B` sector sizes (`2` blocks per KB), and your database writes in `8KB` chunks, then your database writes `16` blocks per write extent and RSORT would improve the rescan times.

---

1. First determine the number of blocks that are formatted for each device.

   a. This information is visible when you format the device using the `fio-format` utility.

   b. Or you can estimate the number of blocks using the total device capacities and their formatted sector sizes.

      This example shows a quick estimation of the number of blocks on `1000GB` of IBM io3 Flash Adapter capacity with `512B` size sectors (`2` sectors per KB):

```
1000GB * 1000MB/GB * 1000KB/MB * 1000B/KB * 1 Block/512B = 1,
953,125,000 Blocks
```

2. Divide the number of blocks by the write extents per block to determine the total possible number of write extents on the device(s).

    a. In the example above there were `1.95 billion` blocks. We will assume `16KB` write extents (`32 blocks` per write on 512B sectors):

```
1,953,125,000 Blocks * 1 Write Extent/32 Blocks = 61,035,156
Writes
```

3. Multiply the number of writes by 32 bytes of RAM per write (and translate that into MiB) to determine the memory target for this parameter.

    a. In the example above there were `61 million` write extents:

```
61,035,156 Writes * 32B/Write * 1KiB/1024B * 1MiB/1024KiB =
~1863MiB of RAM
```

    b. In this example, you would want to set the RSORT limit to about 2300 MiB of RAM available in your system for 1000GB of IBM io3 Flash Adapter capacity formatted for 512B sectors.

NOTE-

Default Value

The RMAP parameter is, by default, set to `0`m and it has a maximim of 100000 (100GiB).

---

4. Set the module parameter to the value you have determined. See See fio-config on page 33 for more information on setting parameters.

Appendix A - Command-line Utilities Reference

The ioMemory VSL software installation packages include various command-line utilities, installed by default in `C:\Program Files\Common Files\VSL Utils`. These provide a number of useful ways to access, test, and manipulate your device.

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 ioMemory VSL utilities), and you should not use them directly unless Customer Support advises you to do so.

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**.)

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.

Utility	Purpose
`fio-attach`	Makes an IBM io3 Flash Adapter available to the OS.
`fio-beacon`	Lights the IBM io3 Flash 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 io3 Flash Adapter from OS access.
`fio-format`	Used to perform a low-level format of an IBM io3 Flash Adapter.
`fio-pci-check`	Checks for errors on the PCI bus tree, specifically for IBM io3 Flash Adapters.
`fio-status`	Displays information about the device(s).
`fio-sure-erase`	Clears or purges data from the device.
`fio-update-iodrive`	Updates the IBM io3 Flash Adapter's firmware.

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 io3 Flash Adapter and makes it available to the operating system. This creates a block device in `/dev` named `fiox` (where `x` is `a`, `b`, `c`, etc.). You can then partition or format the IBM io3 Flash Adapter, or set it up as part of a RAID array. The command displays a progress bar and percentage as it operates.

NOTE-

In most cases, the ioMemory VSL software 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 software's auto_attach parameter to 0.

NOTE-

If the IBM io3 Flash 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 of the device node (`/dev/fctx`), where *x* indicates the device number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM io3 Flash Adapter detected on the system.

You can specify multiple IBM io3 Flash Adapters. For example, `/dev/fct1 /dev/fct2` indicates the second and third IBM io3 Flash Adapters installed on the system.

Option	Description
`-r`	Force a metadata rescan. This may take an extended period of time, and is not normally required. **Attention!** Only use this option when directed by Customer Support.
`-c`	Attach only if clean.
`-q`	Quiet: disables the display of the progress bar and percentage.
`-Q`	Quiet: disables the display of the progress bar only.

fio-beacon

Description

Lights the IBM io3 Flash Adapter's LED to locate the device. You should first detach the IBM io3 Flash Adapter and then run `fio-beacon`.

Syntax

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

where `<device>` is the name of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM io3 Flash Adapter detected on the system. The device numbers are visible using `fio-status`.

Option	Description
`-0`	Off: (Zero) Turns off the beacon.
`-1`	On: Lights the LED beacon (slow flash).
`-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 contact Customer Support at 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\Common Files\VSL Utils`) in a `.cab` file that indicates the date and time the utility was run.

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-20090921_173256.cab.
  Please attach this file to your support case.
  If you do not have an open support case for this issue, please open a
support
  case with a problem description and then attach this file to your new
case.
```

For example, the filename for a bug report file named `fio-bugreport-20090921_173256.cab` indicates the following:

- Date: 20090921 (YYYY:MM:DD)
- Time: 173256, or 17:32:56

fio-config

Description

Sets and gets ioMemory VSL software configuration parameters for device operation. For a list of parameters, see **Parameters Reference** below.

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 io3 Flash Adapters in the **Device Manager**. This will reload the ioMemory VSL software with the values(s) enabled. Be sure to use the `-p` option if you plan to reboot.

Syntax

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

where `<parameter>` is the ioMemory VSL software 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.

Parameters Reference

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

Attention!

`fio-config` options must be entered in uppercase to function properly.

MSI (Message Signaled Interrupts) is enabled by default for this platform, and it cannot be disabled using `fio-config`.

Other than `FIO_PREALLOCATE_MEMORY` all `fio-config` options are global{mdash}they apply to all Fusion-io devices in the computer.

Attention!

By setting the `FIO_PREALLOCATE_MEMORY` parameter, you **overwrite previous values**. If you wish to add additional serial numbers to the list, you must list the new serial numbers as well as the previously entered numbers. To clear the list, set the parameter without any values.

Option	Default (min/max)	Description
`AUTO_ATTACH`	`1` (`0`, `1`)	Always attach the device on driver load (`1`).
`IODRIVE_TINTR_HW_WAIT`	`0` (`0`, `255`)	Interval (microseconds) to wait between hardware interrupts.
`FORCE_MINIMAL_MODE`	`0` (`0`, `1`)	Force minimal mode on the device (`1`), this parameter is set to false (`0`) by default.
`PARALLEL_ATTACH`	`0` (`0`, `1`)	Enable parallel attach of multiple devices (`1`), this parameter is set to false (`0`) by default.
`FIO_PREALLOCATE_MEMORY`	`0`	For the selected device, pre-allocate all memory necessary to have the device 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`.

Option	Default (min/max)	Description
rmap_memory_limit_MiB	3100 (0, 100000)	Amount of system memory (RAM) in MiB allocated for improving rescan times after an unclean shutdown. For more information, see See Improving Rescan Times on page 26.
rsort_memory_limit_MiB	0 (0, 100000)	Amount of system memory (RAM) in MiB allocated for improving rescan times after an unclean shutdown. For more information, see See Improving Rescan Times on page 26.
WIN_LOG_VERBOSE	0 (0, 1)	If enabled (1), the ioMemory VSL software will write additional messages to the event log. This will assist Customer Support in troubleshooting any device issues or failures.
WIN_DISABLE_ALL_AFFINITY	0 (0, 1)	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.

Option	Default (min/max)	Description
WIN_DISABLE_DEFAULT_NUMA_AFFINITY	0 (0, 1)	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.
FIO_AFFINITY	N/A	FIO_AFFINITY is a list of <affinity specification> triplets to specify the affinity settings of all adapters in the system. Each item in the triplet is separated by a comma, and each triplet set is separated by a semicolon. **Attention!** For syntax information and examples showing the use of this parameter, see See NUMA Configuration on page 63.

fio-detach

Description

Detaches the IBM io3 Flash Adapter and removes the corresponding fctxIBM io3 Flash Adapter block device from the OS. The fio-detach utility waits until the device completes all read/write activity before

executing the detach operation. By default, the command also displays a progress bar and percentage as it completes the detach.

Attention!

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 of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM io3 Flash Adapter detected on the system.

You can specify multiple IBM io3 Flash Adapters. For example, `/dev/fct1 /dev/fct2` indicates the second and third IBM io3 Flash Adapters installed on the system. You can also use a wildcard to indicate all IBM io3 Flash Adapters on the system. For example, `/dev/fct*`

Option	Description
`-f`	Force: Causes an immediate detach (does not save metadata). **Attention!** Although the `-f` (force) option causes the IBM io3 Flash 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.
`-q`	Quiet: Disables the display of the progress bar and percentage.
`-Q`	Quiet: disables the display of the progress bar only.

Notes

Attempting to detach an IBM io3 Flash Adapter may fail with an error indicating that the device is busy. This typically may occur if the IBM io3 Flash Adapter is part of a software RAID (0,1,5) volume, is mounted, or some process has the device open.

Windows refuses the request to detach the drive associated with the IBM io3 Flash 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 io3 Flash Adapter). To detach in this case, take the volume offline using the Disk Management MMC plug-in application.

fio-format

Description

NOTE-

IBM io3 Flash Adapters ship pre-formatted, so `fio-format` is generally not required except to change the logical size or block size of a device, or to erase user data on a device. To ensure the user data is truly erased, use `fio-sure-erase`, see See fio-sure-erase on page 43 for more information.

Performs a low-level format of the IBM io3 Flash Adapter. 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. You will be prompted as to whether you want to proceed with the format.

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` or `-o` options, the device size defaults to the advertised capacity. If used, the `-s` and `-o` options must include the size or percentage indicators.

Attention!

We recommend adding power backup to your system to prevent power failures during formatting.

Syntax

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

where `<device>` is the name of the device node (`/dev/fctx`), where *x* indicates the device number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM io3 Flash Adapter detected on the system. Use `fio-status` to view this number.

Options	Description

`-b <size B|K>`	Set the block (sector) size, in bytes or kibibytes (base 2). Only 512b or 4KiB sector sizes are supported. For example: `-b 512B` or `-b 4K` (`B` in `512B` is optional). io3 Enterprise Value Adapters and io3 Enterprise Adapters ship with 4KiB sectors sizes. If you do not specify a sector size, the utility will format the sectors to the default size of 4KiB sector sizes.
`-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: Disable the display of the progress and percentage indicators.
`-Q`	Quiet: disables the display of the progress bar only.
`-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)
`-R`	Disable fast rescan on unclean shutdown to reclaim some reserve capacity.
`-y`	Auto-answer "yes" to all queries from the application (bypass prompts).

You must re-attach the device in order to use the IBM io3 Flash Adapter. See See fio-attach on page 31 for details.

fio-pci-check

Description

Checks for errors on the PCI bus tree, specifically for IBM io3 Flash Adapters. This utility displays the current status of each IBM io3 Flash Adapter. It also prints the standard PCI Express error information and resets the state.

NOTE-

It is perfectly normal to see a few correctable errors 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 software must be loaded to run this utility. Some PCI errors cannot be reset in Windows.

Syntax

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

Option	Description
`-d <value>`	`1` = Disable the link; `0` = bring the link up (Not recommended).
`-e`	Enable PCI-e error reporting.
`-f`	Scan every device in the system.
`-n`	Do not perform any writes to config space. Will prevent errors from being cleared.
`-o`	Optimize the IBM io3 Flash Adapter PCIe link settings by increasing the maximum read request size if it is too low.
`-r`	Force the link to retrain.
`-v`	Verbose: Print extra data about the hardware.

fio-status

Description

Provides detailed information about the installed devices. This utility operates on either `fctx` or `fiox` devices. The utility depends on running as root and having the ioMemory VSL driver loaded. If no driver 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 of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM io3 Flash Adapter detected on the system.

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

Option	Description
`-a`	Report all available information for each device.
`-e`	Show all errors and warnings for each device. This option is for diagnosing issues, and it hides other information such as format sizes.
`-c`	Count: Report only the number of IBM io3 Flash 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.
`-fj`	Format JSON: creates the output in JSON format.
`-fx`	Format XML: creates the output in XML format.
`-u`	Show unavailable fields. Only valid with `-fj` or `-fx`.
`-U`	Show unavailable fields and details why. Only valid with `-fj` or `-fx`. **NOTE-** Some `fio-status` fields are unavailable depending on the operating system or device. For example, some legacy fields are unavailable on newer IBM io3 Flash Adapters.
`-F<field>`	Print the value for a single field (see the next option for field names). Requires that a device be specified. Multiple `-F` options may be specified.
`-l`	List the fields that can be individually accessed with `-F`.
`-L`	List all the available ioMemory devices on the system.

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

- Number and type of devices installed in the system
- ioMemory VSL software version

Adapter information:

- Adapter type
- Product number
- Product UUID
- PCIe power limit threshold (if available)
- Connected IBM io3 Flash Adapters

Block device information:

- Attach status
- Product name
- Product number
- Serial number
- PCIe address and slot
- Firmware version
- Size of the device, out of total capacity
- Internal temperature (average and maximum, since ioMemory VSL software 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
- Part number
- Date of manufacture
- Power loss protection status
- PCIe bus voltage (avg, min, max)
- PCIe bus current (avg, max)
- PCIe bus power (avg, max)
- PCIe power limit threshold (watts)
- PCIe slot available power (watts)
- PCIe negotiated link information (lanes and throughput)
- Product UUID

Block device information:

- Manufacturer's code
- Manufacturing date
- Vendor and sub-vendor information
- Format status and sector information (if device is attached)
- Controller 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
- RAM usage

Error Mode Information: If the ioMemory VSL software 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 io3 Flash 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 `fio-format` before using the device again, see See fio-format on page 38.

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 http://www.ibm.com/systems/support for further assistance.

In order to run `fio-sure-erase`, the block device **must be detached**. See See fio-detach on page 36 section for more information.

Description

The `fio-sure-erase` is a command-line utility that securely removes data from IBM io3 Flash 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 of the device node (`/dev/fctx`), where *x* indicates the card number: 0, 1, 2, etc. For example, `/dev/fct0` indicates the first IBM io3 Flash Adapter detected on the system. Use `fio-status` to view this device node, see See fio-status on page 40.

Option	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.
`-t`	Do not preserve current format parameters, including device and sector size (reset to default).
`-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.

When the utility completes, 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-update-iodrive

Attention!

You should back up the data on the IBM io3 Flash Adapter prior to any upgrade as a precaution.

Description

Updates the IBM io3 Flash Adapter's firmware. This utility scans the PCIe bus for all IBM io3 Flash 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 ioMemory VSL driver after each firmware upgrade step. Otherwise the on-device format will not be changed, and there will be data loss. For more information on staged upgrades, see the *IBM ioMemory VSL Release Notes*.

Attention!

Do not use this utility to downgrade the IBM io3 Flash Adapter to an earlier version of the firmware. Doing so may result in data loss and void your warranty. Contact IBM System x Customer Support at http://www.ibm.com/systems/support if you have issues with your upgrade.

NOTE-

The default action (without using the `-d` option) is to upgrade all IBM io3 Flash Adapters with the firmware contained in the `fio-firmware-highiops-<version>.<date>.fff` firmware archive 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!

Upgrade Path

There is a specific upgrade path that you must take when upgrading IBM io3 Flash Adapter. Consult the *IBM ioMemory VSL Release Notes* for this ioMemory VSL software release before upgrading IBM io3 Flash Adapters.

NOTE-

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

To update one or more specific devices:

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

Online Firmware Updates

This utility will upgrade compatible IBM io3 Flash Adapters while attached. The utility will check to make sure the device(s) support live firmware upgrades (while attached).

NOTE-

The firmware update will not take effect until you restart the system. If you have updated the firmware, but not restarted, the fio-status utility will report the following:

```
...
Firmware vX.X.X, rev 115781 Public
       Unactivated Firmware vX.X.Y, rev XXXXXX -- Reboot required to
activate     <-------
```

If a device is not compatible, the `fio-update-iodrive` utility will return an error that the device is not supported. In this case, you will need to first detach the device and then run this utility again. In either case, you must restart the system before the updated firmware will take effect.

Syntax

```
fio-update-iodrive [options] <firmware-path>
```

where `<firmware-path>` is the full path to the firmware archive file `fio-firmware-highiops-<version>.<date>.fff` available at http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-65723 (follow that link and then select **IBM High IOPS and io3 software matrix**). If you downloaded the `.fff` firmware archive file, then the firmware is most likely with the other downloaded packages.

Option	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` option with care, as updating the wrong IBM io3 Flash Adapter could damage your device.
`-f`	Force upgrade (used only when directed by Customer Support). **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.
`-c`	Clears locks placed on a device.
`-q`	Quiet: Runs the update process without displaying the progress bar or percentage.
`-Q`	Quiet: Only disable the progress bar.
`-y`	Confirm all warning messages.

If you arrived at this section from See Upgrading the Firmware on page 12, you should return to that section.

Appendix B - Troubleshooting Event Log Messages

The Windows System Event Log displays the following messages concerning the IBM io3 Flash Adapter: Informational, Warnings, and Errors.

NOTE-

Each IBM io3 Flash Adapter is numbered from `0` upwards. Use the `fio-status` utility to view this number for your device.

Attention!

While these messages are very useful for troubleshooting purposes, the ioMemory VSL log messages are not designed for continual monitoring purposes (as each is based on a variety of factors that could produce different log messages depending on environment and use case). For best results, use the tools described in See Monitoring and Managing Devices on page 19 to regularly monitor your devices.

Verbose Event Log Parameter

If you begin experiencing issues with your IBM io3 Flash Adapters, you should enable the `WIN_LOG_VERBOSE` ioMemory VSL parameter. This will expand the extent of the ioMemory VSL error log messages in the event log and provide additional crucial information for troubleshooting any issues.

Sample Command:

```
fio-config.exe -p WIN_LOG_VERBOSE 1
```

For more information on enabling parameters, see See fio-config on page 33.

Viewing Logs

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.	Follow the instructions in See Upgrading the Firmware on page 12 to update the firmware.
Error: ioDrive initialization failed with error code `0xerrorcode`*	1. Reinstall the Windows ioMemory VSL. 2. Remove and reseat the IBM io3 Flash Adapter. 3. Remove and insert the IBM io3 Flash 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 `[fio-attach]` command-line utility or IBM Flash Management Console 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 io3 Flash 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 Flash Management Console. 2. Select your unattached IBM io3 Flash 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 See Enabling Auto-Attach on page 25.

* Where `0xerrorcode` is one of the following:

Error Code	Description

0xFFFFFC00	Uncorrectable ECC Error
0xFFFFFBFF	Uncorrectable ECC Error
0xFFFFFBFE	Invalid Media Format
0xFFFFFBFD	Unknown Error

Or one of the 43 standard Windows errno definitions found at http://msdn.microsoft.com/en-us/library/t3ayayh1%28v=vs.110%29.aspx

Attention!

The error code is converted to a negative number, and then reported in hexadecimal format. For example, `errno=1` is converted to `-1` and is represented as `0xFFFFFFFF`, and `errno=1024` is converted to `-1024` and is represented as `0xFFFFFC00`.

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 See fio-config on page 33 for more information about affinity settings.

Appendix C - Manual Installation

The Windows Setup program will install ioMemory VSL software on your Windows operating system. However, there are some instances where you may need to manually install the software for a particular IBM io3 Flash Adapter, including:

- After a software installation (including upgrade), IBM io3 Flash Adapters don't show up in `fio-status`.
- You install new IBM io3 Flash Adapters on a system that has previously installed IBM io3 Flash Adapters and ioMemory VSL software.

Follow the steps below forWindows Server 2008. This will ensure that the ioMemory VSL software is installed for a particular device. Repeat the steps for each device, if needed.

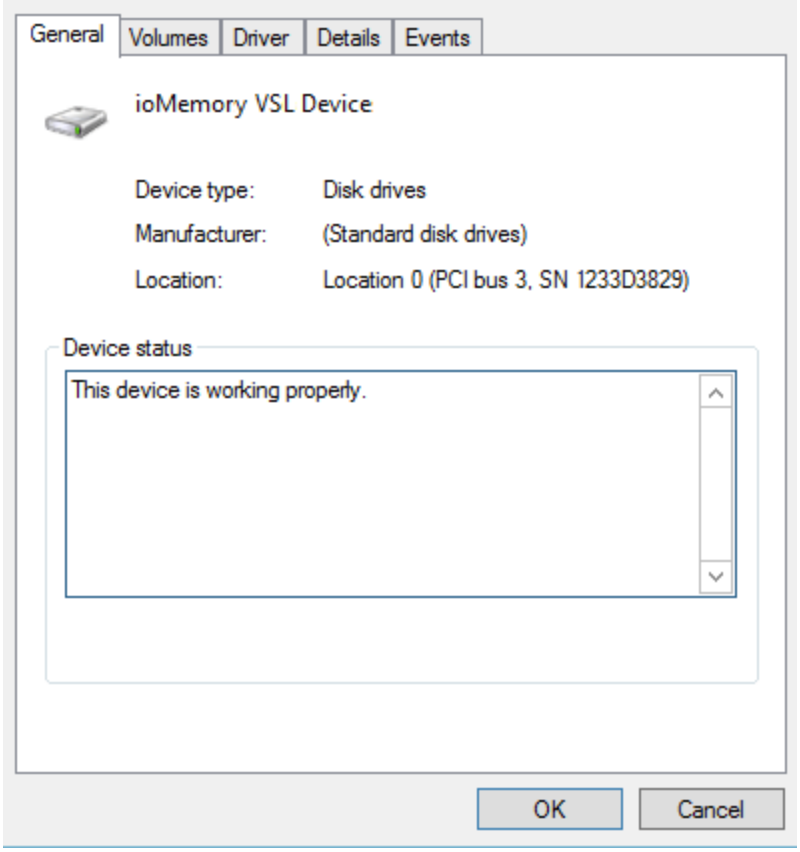
Manual Install on Windows Server 2008 R2 and 2012

Before you manually install the ioMemory VSL software, make sure you have downloaded and run the ioMemory VSL Windows Setup program from http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-65723 (follow that link and then select **IBM High IOPS and io3 software matrix**). This will install the ioMemory VSL software on the system, and you will now be able to install the ioMemory VSL software for each IBM io3 Flash Adapter.

The Windows Driver Wizard may automatically detect the new IBM io3 Flash Adapter and starts to locate its ioMemory VSL software after you restart the system. If this happens, you may skip to the Installation Wizard procedure below.

1. Launch the Device Manager.
   - In Windows Server 2008, choose **Start** > **Control Panel** > **Device Manager**.
   - In Windows Server 2012, from the **Server Manager** select **Tools** (in the upper right) > **Computer Management** > **Device Manager**.
2. Select **Fusion ioMemory VSL devices**.
3. Click on your IBM io3 Flash Adapter(s) in the list. The Properties dialog box appears.

> **Attention!**
> The device may be titled `Mass Storage Controller`.



a. If the **Device Status** reads `This device is working properly`, then the ioMemory VSL software has been installed.

b. If the device is not working correctly, you will need to manually install the software for that device. Continue with the manual installation.

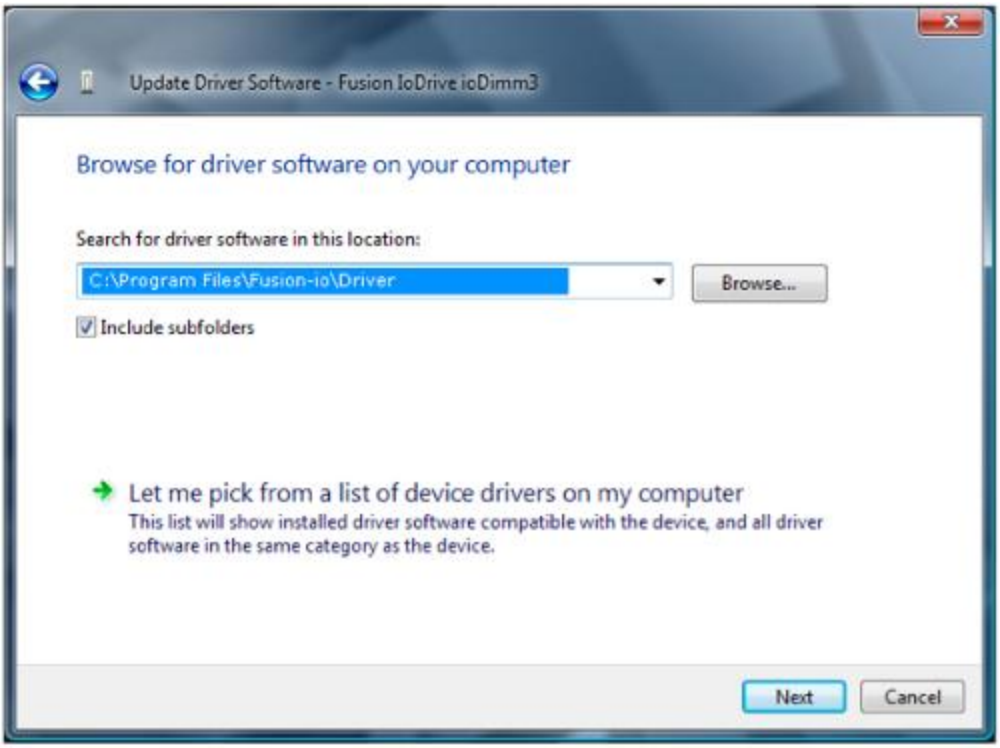
4. Close the Properties dialog box.

5. Right-click on the device and choose **Update Driver**.

6. Follow the instructions below.

Installation Wizard

1. Windows will ask you to locate the software driver.



2. Click **Browse** next to the path field. Windows displays a file dialog.
3. Select the folder with the ioMemory VSL software (the default is `C:\Program Files\IBM HIGH IOPS\<VSL-Version>\Driver`).
4. Click **OK**.
5. Click **Next**.
   Windows finds the correct software and installs the device software. When the driver installation completes,
6. Restart the computer.
7. Proceed to See Upgrading the Firmware on page 12 to continue.

Appendix D - Monitoring the Health of Devices

This section describes how the health of IBM io3 Flash Adapters can be measured and monitored in order to safeguard data and prolong device lifetime.

Health Metrics

The ioMemory VSL software manages block retirement using pre-determined retirement thresholds. The IBM Flash Management Console 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 Health Monitoring Techniques on page 54 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 io3 Flash 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 io3 Flash 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.

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 io3 Flash 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 wear out.

NOTE-

For service or warranty-related questions, contact IBM System x Customer Support.

NOTE-

For products with multiple IBM io3 Flash Adapters, these modes are maintained independently for each device.

Health Monitoring Techniques

`fio-status -a`: Output from the `fio-status` utility (using the `-a` option) shows the health percentage and device state. These items are referenced as "`Reserve space status`" in the sample output below.

```
Found 1 ioMemory device in this system
Driver version: 4.x.x build xxxx
...
Reserve space status: Healthy; Reserves: 100.00%, warn at 10.00%
Lifetime data volumes:
   Physical bytes written: 6,423,563,326,064
   Physical bytes read   : 5,509,006,756,312
```

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

- Healthy
- 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 io3 Flash Adapter attempts to fail as gracefully as possible, and these new failure mechanisms are compatible with existing software RAID stacks. An IBM io3 Flash 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 E - Using the Windows Page Files

Introduction

This appendix describes how to effectively use paging (also called swap or Virtual Memory) files on IBM io3 Flash 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 io3 Flash Adapters allows much larger page files and usable virtual memory. This is due to the much faster response times and bandwidth on IBM io3 Flash Adapters versus hard disks.

Configuring Device Paging Support

The ioMemory VSL software can be configured to support paging files on one or more IBM io3 Flash Adapters. This requires that each IBM io3 Flash 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 device instance.

Because of the extra host RAM memory use, paging should be enabled only on IBM io3 Flash Adapters that will actually hold a paging file. It is possible to place a single paging file on more than one IBM io3 Flash 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 io3 Flash Adapter depends on the device's total size and the sector (block) size selected when formatting the drive (with `fio-format`).

NOTE-

Consult the Release Notes for this version of the software for RAM usage per GB of IBM io3 Flash 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 are compatible only with 512-byte sector sizes.

The indicated amount is needed per IBM io3 Flash Adapter that supports paging. You must carefully plan which IBM io3 Flash Adapter(s) will be used to hold a paging file.

Non-paged Memory Pool

Pre-allocated memory for the IBM io3 Flash 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 to 75% 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 io3 Flash Adapter pre-allocates RAM, and that reduces the available physical non-paged memory. The ioMemory VSL software 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 io3 Flash Adapters, let's use the following example:

- One IBM io3 Flash 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 software 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 software 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 io3 Flash Adapters that will support a paging file. The ioMemory VSL software 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 io3 Flash 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 Flash Management Console.

NOTE-

You must reload the ioMemory VSL software 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 io3 Flash 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

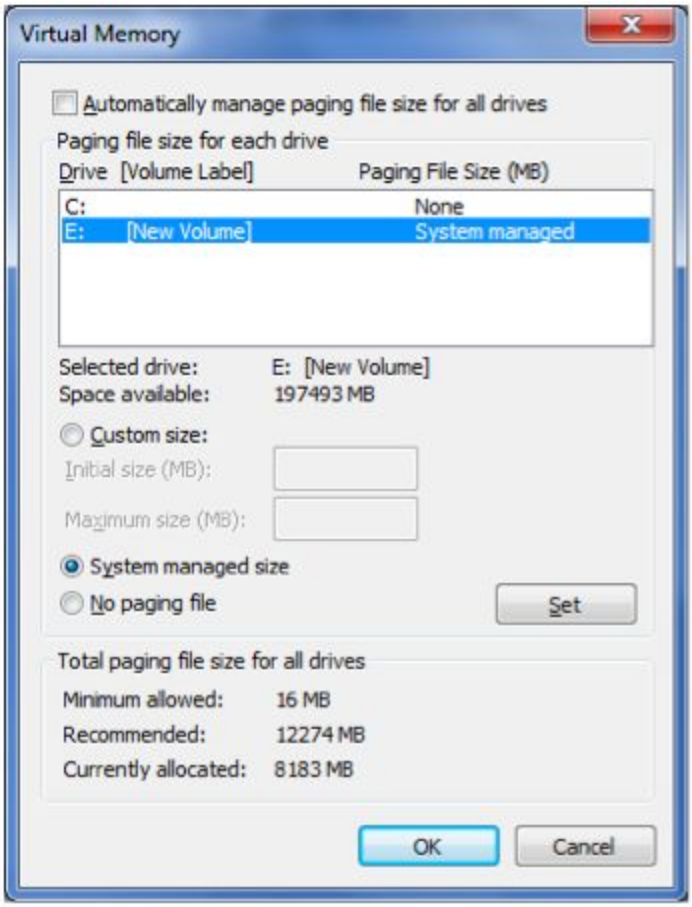
By default, the ioMemory VSL software disables support for page files. The previous section described how to enable support for page files on one or more IBM io3 Flash Adapters. The following describes how to work with the built-in Windows control panels to configure and set up paging files on IBM io3 Flash 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 io3 Flash Adapter with a paging file.

Windows supports up to 16 distinct paging files. To enable a page file on an IBM io3 Flash Adapter,

1. Choose the IBM io3 Flash Adapter from the device list.
2. Select the **Custom size** radio button.
3. Provide values in the **Initial size** and **Maximum size** fields.
4. When prompted to restart, click **Yes**. This is necessary for the new page file settings to take effect.
5. Click **Set** to save the setting. Do not omit this step, or your changes will be lost.
6. Click **OK**.

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 io3 Flash Adapters, even if the IBM io3 Flash 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 io3 Flash 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 io3 Flash 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 io3 Flash 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 io3 Flash 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 io3 Flash 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.

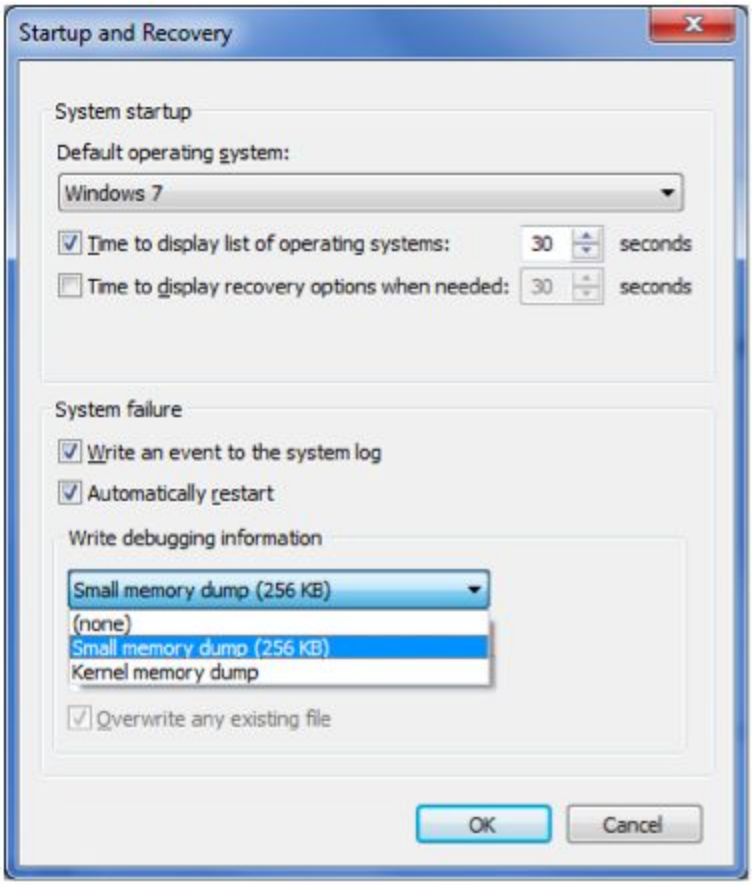
3. Create a page file large enough for a full-kernel memory dump. This typically requires a page file at least the size of installed RAM, with some recommending the size equal to RAM x 1.5.

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: Pushing the Limits of Windows
- Specific section that documents virtual memory: Pushing the Limits of Windows: Virtual Memory

Verifying Page File Operation

To verify that a page file is actively placed on an IBM io3 Flash 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 io3 Flash Adapter.

Page File Performance

Using an IBM io3 Flash 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 F - NUMA Configuration

Attention!

Deprecated Parameters

The NUMA node parameters are deprecated. The ioMemory VSL software now automatically creates interrupt affinity between IBM io3 Flash Adapters and NUMA nodes. However, you may still use this appendix and these parameters to manually configure NUMA node affinity.

About NUMA Architecture

Servers with a NUMA (Non-Uniform Memory Access) architecture may require special installation instructions in order to maximize IBM io3 Flash Adapter performance. This includes most multi-socket servers.

On some servers with NUMA architecture, during system boot the BIOS will not associate PCIe slots with the correct NUMA node. Incorrect mappings result in inefficient I/O handling that can significantly degrade performance.

Using the `FIO_AFFINITY` Parameter

Use this parameter to map devices with specific NUMA nodes.

Attention!

The example below shows the final implementation of custom affinity settings. This implementation required an analysis of the specific system, including the system architecture, type and number of IBM io3 Flash 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 and determine the `<device-id>` (see below). Then use the example below of setting the `FIO_AFFINITY` parameter as a template and modify it for your particular system.

Determining the Bus Number

In order to create the correct settings for your specific system, use `fio-status` to list all of the devices' bus numbers. For example:

```
fio-status
Found 2 ioMemory devices in this system
```

```
...
        PCI:04:00.0
...
        PCI:0F:00.0
```

Attention!

In Windows, the bus number is displayed in hex, but you need to enter the number in decimal. In this example, `04` is `4` and `0F` is `15`.

Attention!

Note that the PCI device ID, including the bus number, may change if you change any of the PCI devices in the system. For example, if you add a network card or another IBM io3 Flash Adapter. If the device ID changes, you will have to update the configuration.

FIO_AFFINITY Parameter

Configuring your IBM io3 Flash Adapters for servers with NUMA architecture requires the use of the `FIO_AFFINTIY` parameter with the fio-config utility.

The `FIO_AFFINITY` parameter is a list of `<affinity specification>` triplets that specify the affinity settings of all devices in the system. Each item in the triplet is separated by a comma, and each triplet set is separated by a semicolon.

Syntax:

```
fio-config -p FIO_AFFINITY <affinity specification>[;<affinity
specification>...]
```

Where each `<affinity specification>` has the following syntax:

```
<[domain number:]bus number>,[g|n]<group or node number>[,<hex mask>]
```

If domain number is not specified, it will be set to `0` (most common).

If there is no g or n character before the group/node number, then the number is assumed to be a group number.

The hex mask is optional. If it is not present, the mask is assumed to be `0xffffffffffffffff`. Also, the `0x` prefix is optional.

If the hex mask is a node mask, then the mask is relative to the node, not the group to which the node belongs.

Simple Example:

```
fio-config -p FIO_AFFINITY 1:7,n0,0xf;20,n1;80,7;2:132,4,0xff0
```

Has the effect of creating :

PCI Address (domain:bus)	Node/Group	Processor Affinity
1:7	node 0	processors 0 to 3 in the node (mask 0xf)
0:20	node 1	all processors in the node (no hex mask)
0:80	group 7	all processors in the group (no hex mask)
2:132	group 4	processors 4 to 11 in the group (mask 0xff0)

Advanced Configuration

If your server has multiple NUMA nodes and multiple IBM io3 Flash Adapters installed, you will need to make sure that the IBM io3 Flash Adapters are spread out among the various nodes.

While it may be optimal to pair devices to nodes that are electronically closer each device's PCIe slot (which would require an advanced understanding of your server's NUMA architechure and an analysis of the device installation), just simply spreading out all of the devices' node affinity among the available nodes should result in improved performance.

Checking the Log for Errors

If you enter a configuration that is not valid, then the settings will be disabled and an error will be available in the system logs.

For example:

```
fio-config -p FIO_AFFINITY 5,g0,0xf;6,0xf
```

In this example, the affinity for device `fct6` is set incorrectly, because there is no group/node number before the mask. The following errors appear in the system log:

```
2011-09-09T12:22:15.176086800Z - ERROR - FusionEventDriver - FIO_AFFINITY:
Invalid group or node number
2011-09-09T12:22:15.176086800Z - ERROR - FusionEventDriver - Invalid FIO_
AFFINITY parameter syntax at character 13: "5,g0,0xf;6,0x". Manual
affinity settings are disabled!
```

```
# fio-status
Found 2 ioMemory devices in this system
...
       PCI:04:00.0
...
       PCI:0F:00.0
```

Attention!

In Windows, the bus number is displayed in hex, but you need to enter the number in decimal. In this example, `04` is `04` and `0F` is `15`.

In the example above the device IDs would be `0000:04:00.0` and `0000:15:00.0` on a system that had a domain of `0000`.

Attention!

Note that the PCI device ID may change if you change any of the PCI devices in the system. For example, if you add a network card or another IBM io3 Flash Adapter. If the device ID changes, you will have to update the configuration.

FIO_AFFINITY Parameter

Configuring your IBM io3 Flash Adapters for servers with NUMA architecture requires the use of the `FIO_AFFINTIY` parameter with the fio-config utility.

The `FIO_AFFINITY` parameter is a list of `<affinity specification>` couplets that specify the affinity settings of all devices in the system. Each item in the couplet is separated by an equal sign (=), and each couplet set is separated by a comma.

Syntax:

```
fio-config -p FIO_AFFINITY <affinity specification>[,<affinity
specification>...]
```

Where each `<affinity specification>` has the following syntax:

```
<device-id>=<node-number>
```

Simple Example:

```
fio-config -p FIO_AFFINITY 0000:04:00.0=1,0000:1d:00.0=0,0000:05:00.0=2,
0000:1e:00.0=3
```

Has the effect of creating :

<device-id>	Node/Group	Processor Affinity
0000:04:00.0	node 1	all processors in node 1
0000:1d:00.0	node 0	all processors in node 0
0000:05:00.0	node 2	all processors in node 2
0000:1e:00.0	node 3	all processors in node 3

Advanced Configuration

If your server has multiple NUMA nodes and multiple IBM io3 Flash Adapters installed, you will need to make sure that the IBM io3 Flash Adapters are spread out among the various nodes.

While it may be optimal to pair devices to nodes that are electronically closer each device's PCIe slot (which would require an advanced understanding of your server's NUMA architechure and an analysis of the device installation), just simply spreading out all of the devices' node affinity among the available nodes should result in improved performance.

Checking the Log for Errors

If you enter a configuration that is not valid, then the settings will be disabled and an error will be available in the system logs.

For example:

```
fio-config -p FIO_AFFINITY 5,g0,0xf;6,0xf
```

In this example, the affinity for device `fct6` is set incorrectly, because there is no group/node number before the mask. The following errors appear in the system log:

```
2011-09-09T12:22:15.176086800Z - ERROR - FusionEventDriver - FIO_AFFINITY:
Invalid group or node number
2011-09-09T12:22:15.176086800Z - ERROR - FusionEventDriver - Invalid FIO_
AFFINITY parameter syntax at character 13: "5,g0,0xf;6,0x". Manual
affinity settings are disabled!
```

IBM Support

IBM io3 Flash Adapter software and documentation are available on the web at the following address:

http://www.ibm.com/support/entry/portal/docdisplay?lndocid=MIGR-65723 (follow that link and then select **IBM High IOPS and io3 software matrix**).