

Technical white paper

Optimizing performance on Windows 7 for NVMe and other storage devices



This paper details how to achieve optimal storage performance from NVMe devices on Microsoft Windows 7. NVMe is a new storage protocol designed specifically for SSDs. It provides a low latency connection to high-speed storage devices connected directly to the PCIe system bus. Although this paper focuses on Windows 7, you can use many of these steps to improve Windows 10 performance. Correct configuration of the BIOS and OS power states is key.

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Configure power settings

BIOS setting

Configure the system for the highest power state. Keeping cores and buses in high power states reduces the latency of data transactions between memory and the NVMe storage subsystem. Systems with heavy loads—i.e., where all cores are busy and data are transferred consistently—may not require this step. To change the platform power management for the HP Z840, HP Z640, and HP Z440 workstations:

- Enter the BIOS setup by pressing F10 during system boot
- Go to the **Advanced** tab
- Select one of the following methods (both cannot be enabled at the same time).
 - Method 1: power options
 - Disable Runtime power management
 - Set **Idle Power Savings** to **Normal**
 - Disable **Enhanced Halt States** (C1E)
 - Disable **S4/S5 Max Power Savings**
 - Method 2: performance options
 - Enable **PCIe Performance Mode**
 - Go to the **Main** tab, **Save Changes**, and **Exit**.

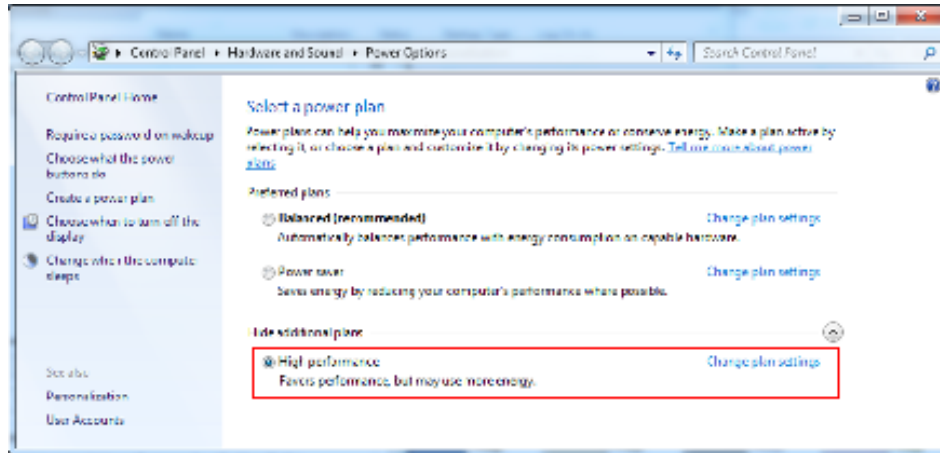
When you enable PCIe Performance Mode using Method 2, the Runtime Power Management, Idle Power Savings, and Turbo mode settings are unavailable. The system optimizes PCIe performance and has the added benefit of improving all storage performance.

For HP ZBooks and HP Z240 desktops, the BIOS can be modified for higher power. This step reduces the system's battery life on HP ZBooks.

- Enter the BIOS setup; press F10 during boot of the HP ZBook.
- From the **Advanced** tab, choose **Power Management Options**.
- Deselect the checkbox for **Runtime Power Management**.
- Deselect **Extended Idle Power States**.

Windows power options

In Windows, go to **Control Panel**, then **Hardware and Sound**, and **Power Options**, then select **High performance**. You may need to click the arrow next to **Show additional plans** to see this option.



Locate the appropriate driver

Although Windows 10 supports NVMe inbox drivers, NVMe was not initially released on Windows 7. Due to customer demand, Microsoft provides two Knowledge Base updates (KBs) that enable NVMe on Windows 7. These KBs are included in SoftPaq SP74909 on HP's Customer Support website, and must be loaded on all Windows 7 images. Customers who create their own images can find instructions for injecting the drivers in customer advisory c05040446, also available on HP's Customer Support website. The Windows 7 driver is also available on the software download site for all HP Desktop and Mobile Workstations under the **Operating System – Enhancements and QFEs** section, as shown below.

Operating System - Enhancements and QFEs (1)

Description	Current version	Size (MB)	Previous version	Download
Microsoft Windows 7 updates to support NVMe (Eastern European, International)	1.00 Rev.A 26 Feb 2016	8.2		Download

To maintain compatibility the Microsoft drive is loaded on all HP Window 7 factory images and HP recommends loading the Microsoft driver on all custom Windows 7 images. Some platforms support vendor-specific drivers that enhance performance or provide access to features on the vendor's drives. If a vendor's driver is supported, you will find it on the platform's support page in the storage section.

Regardless of vendor driver support, the Microsoft driver must be loaded on all Windows 7 images. The vendor-specific driver can then be added. Below is an example of a vendor-specific driver from the HP Z840 driver support page.

Driver - Storage (4)

Description	Current version	Size (MB)	Previous version	Download
Intel Rapid Storage Technology Enterprise Utility and Driver for Microsoft Windows (64 bit Edition) (Eastern European, International)	4.2.0.1136 Rev.A 9 Sep 2015	23.7	4.1.0.1046 B 12 Nov 2011	Download
Samsung NVMe Driver (Eastern European, International)	1.4.7.6 Rev.A 15 Jun 2015	0.34		Download
LSI 2308 SAS Driver - Windows 7 64 (Eastern European, International)	2.00.69.05 Rev.L 6 Oct 2014	1.3		Download
LSI SAS 3270-B1 DRIVER FOR MICROSOFT WINDOWS 7-64bit (International) (Western European, International)	6.702.06.00 F 17 Sep 2014	1.3		Download

Tune Windows to reduce performance variability

When using SSDs on Windows, especially high-performance SSDs like NVMe, the following recommendations can help decrease unwanted load on the storage subsystem, and reduce variability when benchmarking.

TRIM is an ATA command (SCSI Unmap, NVMe Deallocate) that the OS uses to notify an SSD when a block of data is no longer necessary and can be erased. TRIM is specific to ATA, but is commonly used in the industry to describe this erase behavior, regardless of the protocol. You must enable TRIM on Windows 7 and should verify the status by opening a command window and typing:

```
fsutil behavior query disabledeletenotify
```

If the result is “DisableDeleteNotify = 0”, then TRIM is enabled. If it is not enabled, type the command:

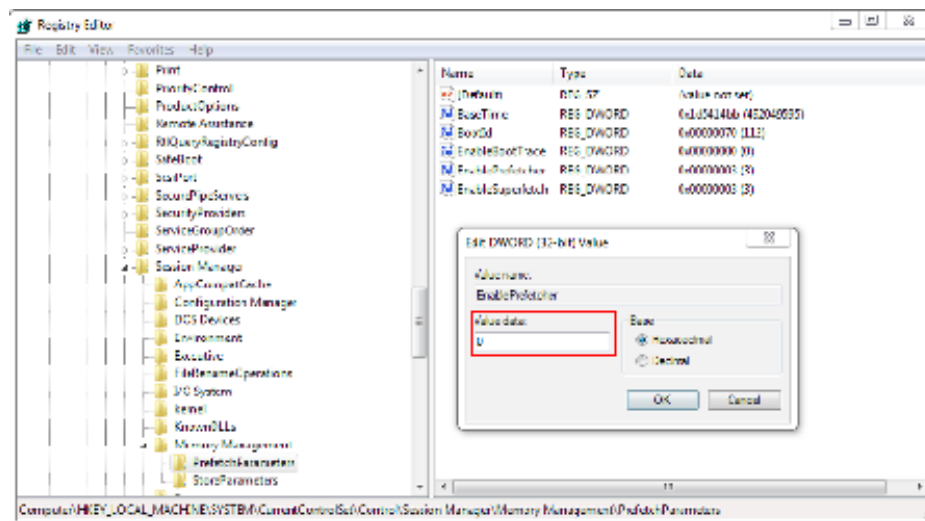
```
fsutil behavior set disabledeletenotify 0
```

Windows has several storage management technologies that can adversely impact performance and create variability when measuring storage performance. These technologies include: Prefetch, Superfetch, and Bootfetch. Windows 7 can't detect an SSD, so you must manually verify and adjust the Windows settings. This is especially true for NVMe SSDs, which arrived late in the Windows 7 support life.

The Windows Prefetch file provides hints to the OS about which files to load when an application starts, or when the system boots. Correct predictions can save time; incorrect predictions can slow data loads. Since NVMe SSDs are fast, a prediction typically is not necessary. An incorrect prediction can dramatically impact benchmarking results, and can cause the results to vary based on the platform's historical use. You can disable Prefetch and Bootfetch by editing the Registry.

NOTE: Use special care when you access the Registry. HP is not responsible for any issues that are a result of changes to the Registry.

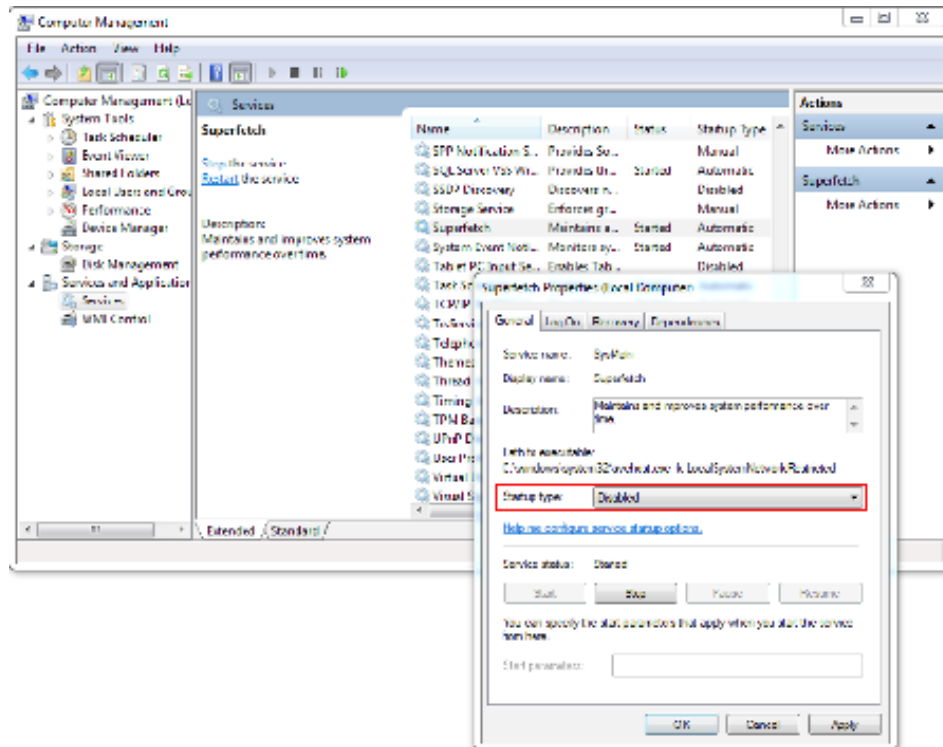
- Run Regedit.
- Navigate to HKEY_LOCAL_MACHINE \ SYSTEM \ CurrentControlSet \ Control \ Session Manager \ Memory Management \ PrefetchParameters.
- Double-click **EnablePrefetcher**.



- The Edit DWORD default value is 3 hex. To disable both Prefetch and Bootfetch, enter the Value as 0, as shown above. The list of values is:
 - » 0 – Disable Prefetcher
 - » 1 – Application launch Prefetch enabled
 - » 2 – Boot Prefetch enabled
 - » 3 – Application launch and Boot Prefetching enabled
- Click **OK**, and exit.

Superfetch uses a prediction algorithm to determine which applications a user will launch next, and Windows preloads the necessary data into memory. Like the other prefetch mechanisms, storage benchmarking results can vary dramatically and this feature should be disabled. The increased speed of NVMe storage subsystems makes this prefetching scheme less useful. Incorrect predictions can impact a user’s current storage performance, leading to lower overall performance. To disable Superfetch:

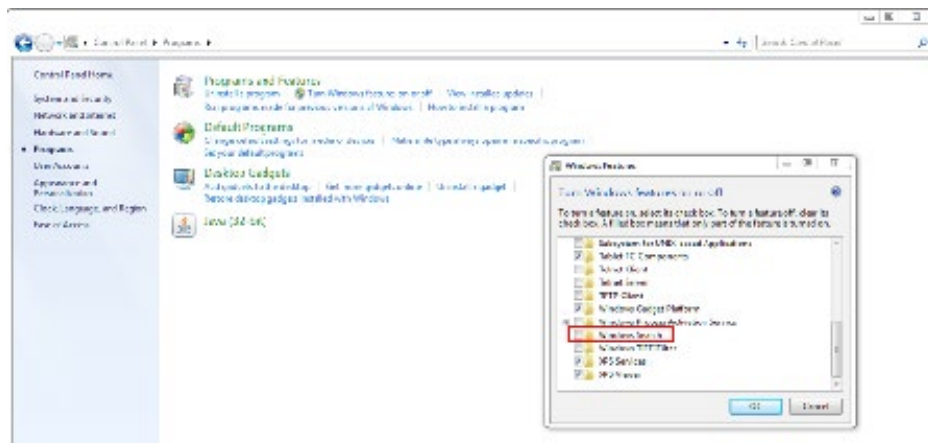
- Open the **Services** manager by typing: “services.msc” in the start menu search box; alternatively, right-click **Computer Management** in the start menu, then **Services and Applications**, then **Services**.
 - Locate **Superfetch** and double-click to open **Superfetch Properties**.
 - Change **Startup type** to “Disabled”.
- Click **Apply** and close the dialog and services windows.



Disable Drive Indexing and Windows Search. This is important on newly installed systems because the background tasks can interfere with storage performance and benchmarking, and can impact current performance for future benefits.

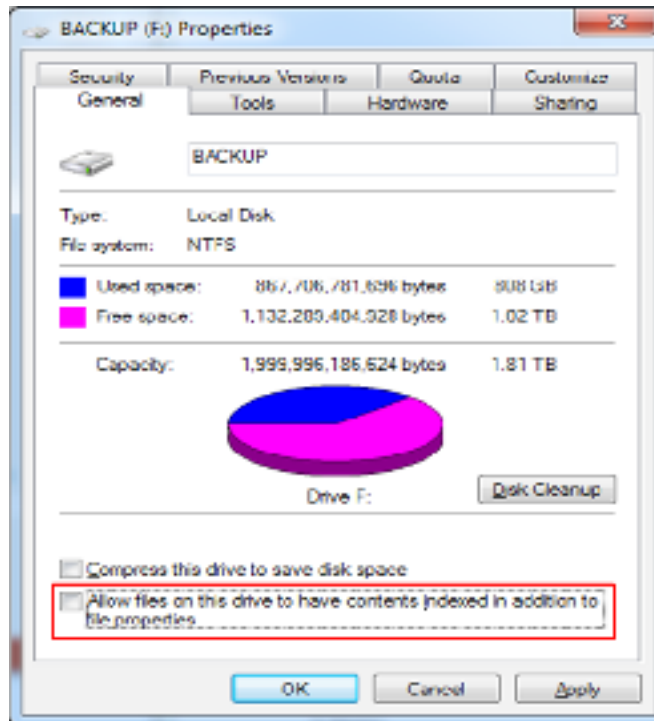
To disable Windows Search:

- Open **Control Panel**, then **Programs**, then **Program and Features**, and **Turn Windows features on or off**.
- Deselect **Windows Search**.
- Click **OK**, and close **Control Panel**.



To disable drive indexing:

- Select and right-click the drive or volume.
- Choose **Properties**.
- From the **General** tab, deselect **Allow files on this drive to have contents indexed in addition to file properties**.
- Click **Apply**, and then **OK**.



Tune the storage subsystem for optimal performance

The following recommendations improve storage performance, but also have trade-offs to consider. Evaluate each recommendation independently, and determine the value of each based on the workload and impact.

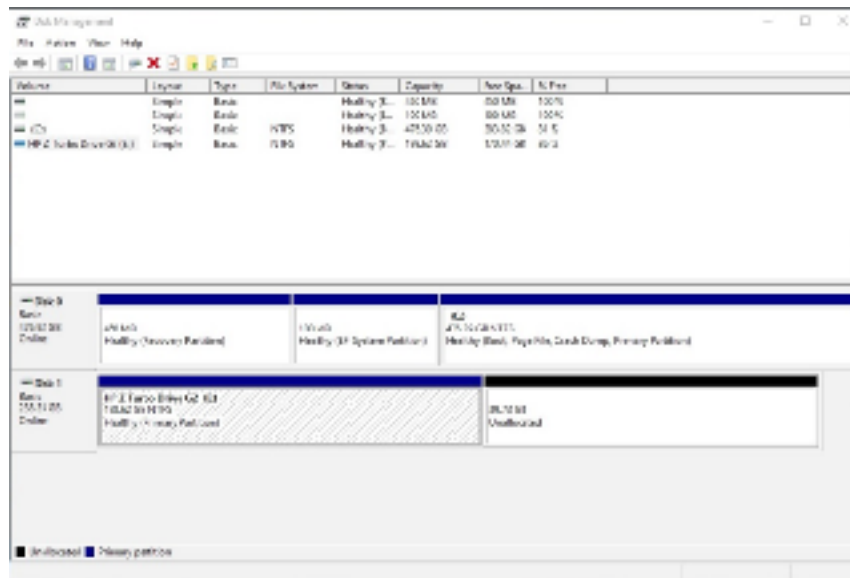
Disk caching is enabled by default, so the DRAM on the NVMe drive can buffer data before reads and writes to the NAND array. This dramatically improves the efficiency of transactions to the NAND array and performance, while also reducing wear.

In the unlikely event of an unexpected power loss, the data in the DRAM is at risk. If the system is in an area where the power grid is unstable, the A/C power cord is regularly unplugged, or the methodology for powering down the system is to press and hold the power button, disable the cache to reduce data loss.

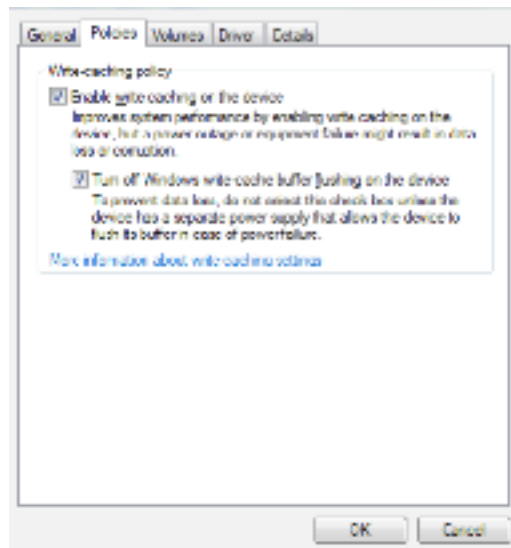
The amount of data at risk is minimized if write cache buffer flushing is enabled, but disabling it can dramatically improve performance. Performance is reduced because the system is overriding the drive's firmware by forcing a flush of the DRAM cache. When both the application and system flush the drive's cache, the performance decreases can be dramatic; use caution when enabling the system to flush the cache.

To enable disk caching and disable write cache buffer flushing:

- In the start menu search box, type “diskmgmt.msc” or right-click the start menu, and select **Disk Management**.

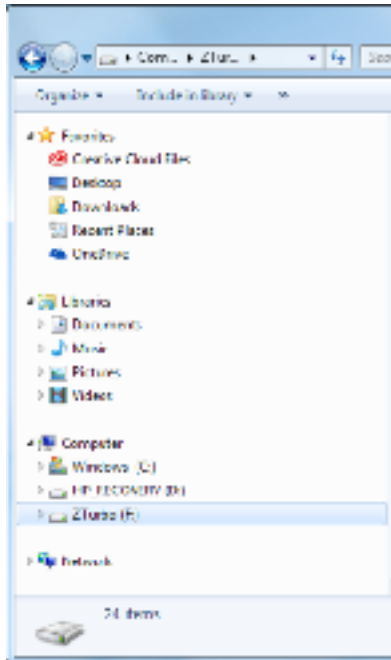


- Hover over the NVMe SSD or volume, and right-click, then choose **Properties**.
- Select the **Policies** tab.
- Select both checkboxes: **Enable write caching on the device** and **Turn off Windows write-cache buffer flushing on the device**, as shown below.

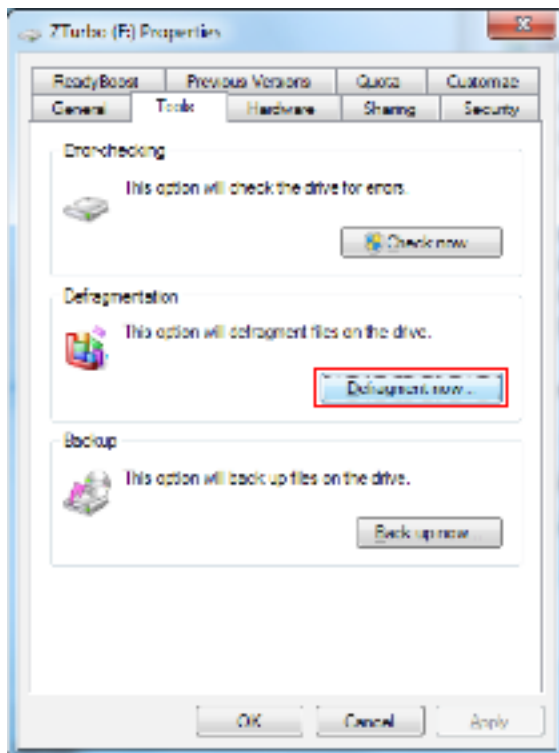


Disable defragmentation of the NVMe SSDs on Windows 7. Defragmentation causes unnecessary movement of data on the SSD and increases wear. To disable defragmentation:

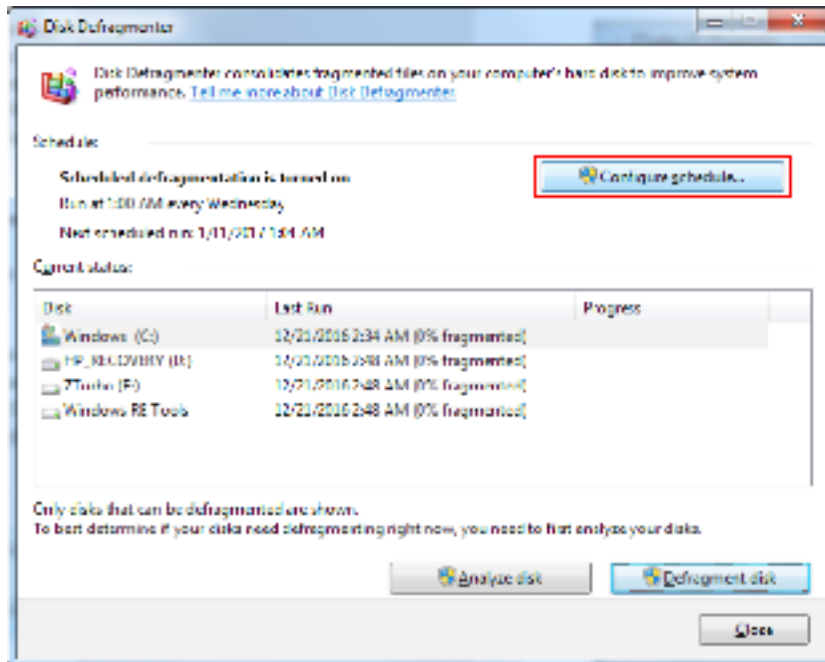
- Select the SSD in Windows Explorer, right-click, and choose **Properties**.



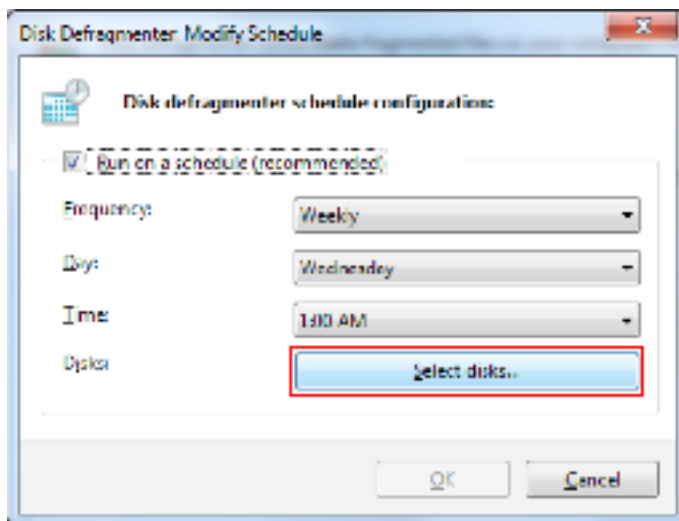
- In the **Tools** tab, click **Defragment now**.



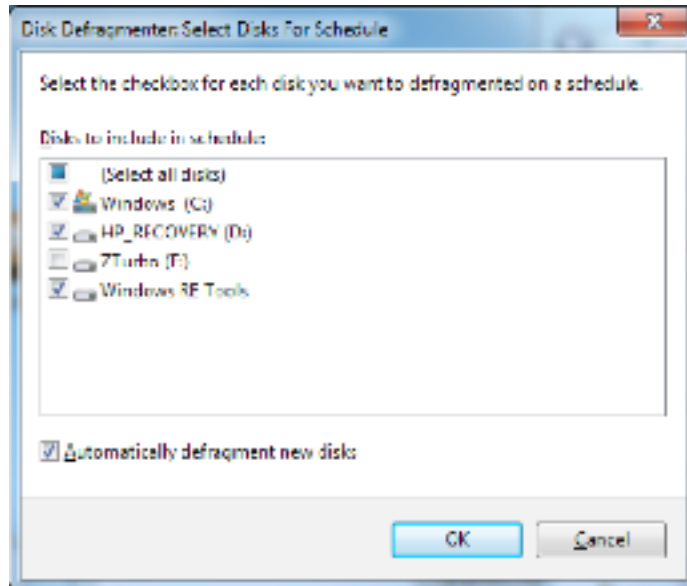
- Click **Configure schedule**.



- Choose **Select disks**.



- Deselect all logical disks (volumes) created on SSDs.



- Accept changes and close all windows.

SSD firmware performs regular maintenance and garbage collection on the NAND array to identify and repair issues with the array, and to detect freed blocks to prepare for reuse. The firmware requires space on the NAND array to operate efficiently. If the SSD is nearly full, the performance and drive life will be impacted.

To maintain performance and drive life, especially in environments where drives are typically filled to capacity, overprovision the drive so that 10% to 20% of the drive remains unallocated, as shown in the Disk Defragmenter screenshot. Overprovisioning reduces the usable capacity of the drive, but increases its performance and extends its lifetime. When benchmarking a drive, make sure the drive is not full and has minimal extraneous data.

Benchmarking considerations

The HP Workstation Storage team offers the following recommendations for benchmarking to produce reliable, consistent results:

- Adjust the system parameters (BIOS and OS) for high performance as described.
- From the BIOS, secure-erase the SSD to get to a known initial state (assuming the SSD under test is not the boot device).
- Precondition the device (a web search will produce several papers on methodology).
- Verify the benchmark version. For example, CrystalDiskMark has a specific version that includes NVMe support.
- Disconnect from the network if it is not needed. This will prevent services from downloading updates while benchmarking. If a network connection is required, disable all services and updates.
- Run the benchmarks repeatedly until a steady state performance level is maintained.
- Record the steady state performance level.

Conclusion

Maximizing performance on high-speed storage devices, such as NVMe SSDs, requires system and OS optimizations. Benchmarking storage devices requires additional care and tuning to achieve consistent results.

Resources

- [SSD Endurance](#)
- [How to choose the right SSD for your workstation](#)
- [Choosing storage solutions for demanding imaging applications](#)
- [NVMe technology for SSDs](#)

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