Windows PC Accelerators

September 30, 2010

Abstract

This paper provides an overview of the Microsoft® Windows® PC Accelerators, a collection of features introduced in Windows Vista® that directly address performance and responsiveness in PCs. This paper describes the key benefits and implementation considerations for each feature.

The PC Accelerators include:

* **Windows SuperFetch**® – analyzes per-machine usage patterns over time and optimizes the data that is kept in memory.
* **Windows** **ReadyBoot** – decreases boot time (the time from turning power on to reaching the log-on screen) by preloading the files and startup programs needed per-machine into a cache.
* **Windows ReadyBoost**® – supports the use of flash storage devices like Universal Serial Bus (USB) flash drives and Secure Digital (SD) flash cards to boost PC performance.
* **Windows ReadyDrive**®– supports hybrid hard disk drives.

This paper is intended for PC and storage device manufacturers that want to develop products to take advantage of the Windows PC Accelerator features.

This information applies to the following operating systems:   
 Windows 7**®**

Windows Vista

References and resources discussed here are listed at the end of this paper.

The current version of this paper is maintained on the Web at:   
 <http://www.microsoft.com/whdc/system/sysperf/perfaccel.mspx>

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Document History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Date | Change |  |  |  |
| September 29, 2010 | Added the new ReadyBoot feature.  Described the Windows 7 improvements for SuperFetch, ReadyBoost, and ReadyDrive.  Clarified descriptions and improved organization throughout. | | | |
| December 4, 2006 | First publication | | | |

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# 

# Overview

The Windows PC Accelerators are a collection of features that improve the performance and responsiveness of Windows client systems. The Windows PC Accelerators include:

* Windows SuperFetch, an innovative memory manager service that analyzes usage patterns over time to optimize memory content.
* Windows ReadyBoot,which decreases the time it takes to boot a PC by preloading into cache the files and startup programs that are needed on the machine. (Boot time is the time it takes to reach the log-on screen after turning on the power.)
* Windows ReadyBoost, a feature that supports the use of flash storage devices to boost system performance.
* Windows ReadyDrive, a feature that supports the use of hybrid hard disk drives (H‑HDDs) on Windows systems.

The Windows PC Accelerators are supported in Windows Vista and later client systems. You can install storage devices that are enhanced for ReadyBoost and ReadyDrive individually or in combination to improve a PC’s performance. You can install ReadyBoost devices internally or externally.

Devices enhanced for ReadyBoost and H‑HDDs enhanced for ReadyDrive are those that meet the performance and implementation requirements described in this document. You can achieve optimal performance by combining ReadyBoost and ReadyDrive devices with ample system main memory. This paper discusses the requirements and recommendations for using the Windows PC Accelerators and provides a summary table.

Although many factors influence the responsiveness and performance of a PC, our research has shown that demand paging is a key contributor to poor performance. (Demand paging is a method of implementing virtual memory that swaps pages of data between disk storage and main memory as needed.) Demand paging generates requests to the disk with long latencies caused by seeks on the disk.

Latencies associated with demand paging can be a result of limited memory capacity; however, they can also be a result of less-than-optimal memory content. The Windows PC Accelerators limit the latencies associated with demand paging in two ways. They provide memory management logic to analyze usage patterns and actively optimize memory content, and they support various implementations of nonvolatile flash memory in PC hardware to provide high-performance disk caching. Although not as fast as main memory, nonvolatile flash memory significantly outperforms disk media in random I/O. Table 1 shows some examples of device latency.

Table 1. Device Latency Examples

|  |  |
| --- | --- |
| Memory type | Latency (milliseconds) |
| Main memory (DRAM) | ~0.0001 |
| Flash memory | ~0.5–1 |
| Disk media (HDD) | ~0.5–24 |

# Windows SuperFetch

SuperFetch works with the memory manager service in Windows to analyze memory usage patterns over time to determine the optimal memory content for a given user for a date or time of day. This differs from the prefetch technique used in Microsoft Windows XP, which preloads data into memory without analyzing usage patterns.

SuperFetch automatically recognizes and uses any additional memory areas available on nonvolatile flash storage devices enhanced for ReadyBoost and ReadyDrive. SuperFetch improves the responsiveness of the system by enabling data retrieval from cached copies instead of slower on-disk storage.

## Memory Management before Windows Vista

Historically, memory management systems have been designed to mitigate the fact that programs frequently requested more memory than the operating system could provide. The operating system used memory management algorithms to mitigate the effects of running low on memory. As a machine ran out of available physical memory, the operating system would free up memory by copying data that was not currently in use and storing it in a pagefile on the disk. This allowed the operating system to give the physical memory capacity to a more active program, while still being able to pull the data back from the pagefile if a program requested it. This process is known as on-demand paging.

## Proactive Memory Population Using SuperFetch

Cheaper memory and larger, more demanding programs have resulted in greatly increased amounts of physical memory in PCs.

SuperFetch uses a lightweight, sophisticated tracking algorithm to determine which pages a user uses most frequently. As a user goes about his daily activities, SuperFetch builds a history of what information is most likely to be needed. To build an effective page list, SuperFetch tracks several aspects of the user’s computing session including foreground application, time of day, day of the week, and whether the user is currently using the PC.

SuperFetch prioritizes the following kinds of pages to remain in memory:

* Pages of applications that are used most frequently overall.
* Pages of applications that are commonly used when resuming:

After extensive hibernation (for example, first thing in the morning).

After shorter periods of sleep or hibernation (for example, after lunch).

SuperFetch continuously maintains preferred content in memory, based on recent usage patterns. SuperFetch distinguishes between user-initiated work and background maintenance tasks initiated by the system when no user tasks are underway (during the idle state). SuperFetch gives higher priority to pages needed for user-initiated tasks over background maintenance tasks.

When the PC has free physical memory, SuperFetch places pages that might be used in the future into the physical memory cache so that Windows can move them directly into the working set instead of pulling them from disk. This provides data when the user needs it, makes the PC more responsive, and eliminates delays due to disk latency.

To illustrate the difference between the memory management techniques of Windows XP and later versions of Windows, consider the common scenario when a user returns to his PC after a lunch break.

While the user is away at lunch, the PC becomes idle, which is an ideal time for maintenance tasks to run without interrupting the user. These programs need memory to run, so the operating system pages the user’s currently open programs out of memory.

In Windows XP, which has no concept of importance or timing, the operating system keeps the user’s programs on disk until the user returns to the PC. Transferring those pages back into memory takes considerable time, during which the PC appears unresponsive.

With Windows Vista and later, SuperFetch knows what applications the user tends to work with when resuming the PC from an idle state, so as soon as the idle tasks are finished, the operating system starts paging the user’s programs back into active memory. When the user returns to the PC, the foreground programs are more responsive.

## Implementation Considerations

SuperFetch is included in client versions of Windows Vista and later. SuperFetch is enabled by default. PC and hardware manufacturers do not need to consider any particular factors in their designs.

To take full advantage of the performance benefits provided by SuperFetch, configure your PCs to include as much main memory as needed to satisfy the expected workload and consider adding internal flash storage device(s) enhanced for ReadyBoost. For information on memory sizing, see the paper titled “Memory Sizing Guidance for Windows 7” listed in “[Resources](#_Resources)” later in this paper.

SuperFetch, ReadyBoot, and ReadyBoost use the same service (sysmain). If you disable the sysmain service, you disable SuperFetch, ReadyBoot, and ReadyBoost.

# Windows ReadyBoot

ReadyBoot decreases system boot time by preloading the files and startup programs that are needed to boot the machine. After every boot, the ReadyBoot service uses idle CPU time to analyze file trace information from the five previous boots and identifies which files were accessed and where they are located on disk. ReadyBoot uses this information to determine which files to prefetch during the next boot. It prefetches the files into an in-RAM cache, eliminating the time that it would take for the boot process to retrieve the files from disk. If available random access memory (RAM) is less than 1.7 GB, ReadyBoot compresses the files in the cache.

ReadyBoot is supported on Windows 7 client systems. ReadyBoot is enabled by default and it is part of the sysmain service. If you disable the sysmain service, you disable ReadyBoot. If SuperFetch detects that the system drive is a fast solid-state drive (SSD) (as measured by Windows Experience Index Disk score), then SuperFetch turns off ReadyBoot.

# Windows ReadyBoost

ReadyBoost supports the use of flash storage devices such as USB flash drives, Secure Digital cards and CompactFlash cards to improve system responsiveness. If a flash storage device supports certain minimum requirements, Windows can use it as a ReadyBoost device. If a flash storage device supports certain higher performance requirements, it can be certified as “enhanced for ReadyBoost”. For information on both levels of requirements, see “[Flash Performance](#_Flash_Performance)” later in this paper.

If a device supports ReadyBoost, it provides a dedicated area where SuperFetch can securely store a copy of performance-crucial data. SuperFetch can retrieve data from a cached copy on nonvolatile flash storage much faster than from disk. SuperFetch typically compresses the data that it writes to the cache at a 2:1 ratio; sometimes it can compress up to a 3:1 ratio. By default, SuperFetch encrypts using 128-bit Advanced Encryption Standard (AES) to ensure security of the data.

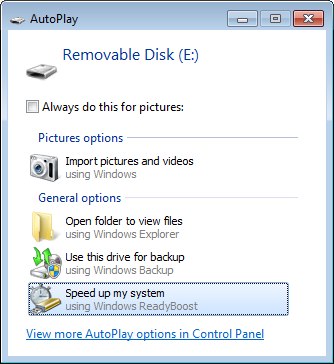
Every page of data in a ReadyBoost cache is a copy of a page on disk. If the flash device is removed from the computer, no data is lost, but the computer loses the performance boost and the operating system reverts to sending requests to the disk.

ReadyBoost data caches have the biggest impact in cases where the user’s workload is significantly larger than RAM size, and on systems with slower disk drives.

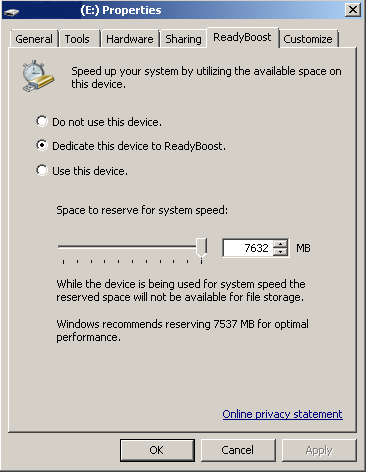
ReadyBoost also allows a user to improve the performance of a machine after its initial purchase by adding external ReadyBoost devices through a USB port and an SD card slot.

## Configuring ReadyBoost Devices

When flash storage devices are installed in a PC, Windows AutoPlay shows a dialog box to the user that includes the option to use the devices with ReadyBoost to improve performance:



If the user selects the option to “Speed up my system using Windows ReadyBoost”, Windows checks whether the device meets the requirements to support ReadyBoost. If the device supports ReadyBoost, Windows displays the following property sheet for the device.



The user can set an appropriate size for the cache on the device. In Windows Vista, the maximum cache size is 4 GB. In Windows 7, the maximum cache size is 32 GB.

The user can configure one or more flash storage devices for ReadyBoost to use as a cache. Windows Vista supports a maximum of one such ReadyBoost cache per machine and the cache can be on an internal or external device. Windows 7 supports a maximum of eight ReadyBoost caches per machine, and the caches can be on a combination of internal and external ReadyBoost devices.

We recommend that the ReadyBoost cache size be at least twice the size of main memory (RAM). Higher ratios provide optimal performance benefits. To create a cache larger than 4 GB, format the ReadyBoost device (USB key, SD card, or other device) using exFAT or NTFS. We recommend using exFAT format for ReadyBoost devices.

## Key Benefits

Devices that support ReadyBoost accelerate the starting of frequently used programs and opening of frequently accessed files and settings. Devices that meet the higher requirements of being enhanced for ReadyBoost provide even greater performance improvement than devices that provide the minimum level of support.

Integrated devices that support ReadyBoost retain data even when the machine is suspended or put into hibernation.

Table 2 describes user scenarios for which ReadyBoost improves performance.

Table 2. Scenarios Where ReadyBoost Improves Performance

|  |  |
| --- | --- |
| Usage scenario | Performance improvement with ReadyBoost |
| Heavy usage of multiple programs concurrently | The flash storage device that supports ReadyBoost provides a dedicated area for SuperFetch data, which can be accessed when the main memory has not yet been populated with SuperFetch data, or when SuperFetch data has recently been forced out of main memory by another request. |
| Poor program start performance while using other programs | During disk contention when many programs are trying to access the disk contents, Windows can access frequently used programs and files on the flash storage device, resulting in more responsive user experiences. |

Using a simulated workload on a PC running Windows Vista with 512 MB of main memory, storage devices of various capacities enhanced for ReadyBoost significantly improve performance (see Table 3).

Table 3. Performance Improvement with Devices Enhanced for ReadyBoost

|  |  |  |
| --- | --- | --- |
| ReadyBoost capacity | Time to complete workload (seconds) | Percent improvement |
| 0 MB | 42.45 | -- |
| 512 MB | 27.12 | 36.12 |
| 1,024 MB | 25.21 | 40.61 |
| 2,048 MB | 24.72 | 41.78 |

**Note:** Running multiple applications on Windows Vista with only 512 MB of main memory creates a lot of contention for main memory. As stated earlier, ReadyBoost provides considerable benefit in configurations with limited main memory. The benefit provided by ReadyBoost is dependent on the system configuration.

On Windows 7 systems with ReadyBoost devices, you can expect performance improvements that are similar to those described for similarly configured Windows Vista systems.

To monitor the effectiveness of ReadyBoost, use the Windows Performance Monitor (PerfMon) tool that is included with Windows. Monitor the **ReadyBoostCache** performance counters. **Bytes Cached** is the amount of data stored in the cache. More bytes in the cache improve the chances for a higher hit-rate. However, more data cached does not guarantee that the cache is effective. The effectiveness of the cache is measured by the hit-rate, which you can obtain from the counters **Cache Read** **Bytes/sec** and **Total Read** **Bytes/sec**. For more information on PerfMon, see “[Resources](#_Resources)” later in this paper.

## Implementation Considerations

The following sections describe the requirements that you must follow to build flash storage devices that can be used by ReadyBoost.

### Supported Form Factors and Busses

ReadyBoost supports all storage devices that have a Windows Assessment Tool (WinSAT) score of 6.5 and above. For example, ReadyBoost supports the following devices:

* USB 2.0 and above flash drives
* Secure Digital cards (SD cards)
* CompactFlash cards
* Memory Stick devices on Peripheral Component Interconnect (PCI), PCI Express (PCIe), and Serial Storage Architecture (SSA) buses, which effectively includes most internal card readers in mobile PCs

To determine the WinSAT score of a device, run the following command from an elevated command prompt:

WinSat disk –read –ran –ransize 4096 –drive E

The above command displays the WinSAT score for drive E. For more information on WinSAT, see “[Resources](#_Resources)” later in this paper.

ReadyBoost supports any flash storage device that exposes a compatible volume to Windows and meets minimum performance limits (see “[Flash Performance](#_Flash_Performance)” later in this paper).

USB flash devices that support ReadyBoost must meet the following requirements:

* The USB flash drives and the host controllers must use the USB 2.0 standard (or above).
* The drives must have at least 230 MB of free space.
* The drives must not be attached to external USB readers.

### Flash Performance

Flash storage devices must meet minimum performance requirements to support ReadyBoost, including:

* 2.5 MB/s throughput for random 4-KB reads
* 1.75 MB/s throughput for random 512-KB writes (on Windows Vista)
* 1.75 MB/s throughput for random 1-MB writes (on Windows 7)

For a device to be designated as “enhanced for ReadyBoost”, it must meet the following higher performance requirements:

* 5 MB/s throughput for random 4-KB reads
* 3 MB/s throughput for random 512-KB writes (on Windows Vista)
* 3 MB/s throughput for random 1-MB writes (on Windows 7)

To take full advantage of the benefits provided by ReadyBoost, we recommend that users use devices that not only support ReadyBoost but are also enhanced for ReadyBoost.

### Flash Capacity

ReadyBoost can support cache sizes ranging from 230 MB to 32 GB. Therefore, you can use ReadyBoost with flash devices that provide capacity in that range.

Microsoft recommends that the ReadyBoost cache size be at least twice the size of main memory (RAM). You can achieve increased performance benefits if the ReadyBoost cache size is more than twice the size of main memory.

### Flash Wear

Some types of nonvolatile RAM (NVRAM) (such as NAND) are rated for a limited number of write-erase cycles before individual cell failure occurs. To limit the possibility of cell failure, ReadyBoost carefully manages when it writes to the cache. Testing of devices enhanced for ReadyBoost indicates that users can expect many years of use under typical workloads. The absolute lifetime of each NVRAM device will vary depending on device specifications.

### PC System Considerations

ReadyBoost is included in client versions of Windows Vista and later. ReadyBoost is enabled by default and is part of the sysmain service. If you disable the sysmain service, you disable ReadyBoost.

### Windows Hardware Quality Labs

The Windows Logo Program for flash storage devices describes the specific performance and capacity requirements discussed in this document. By using Driver Test Manager (DTM) in the Windows Logo Kit (WLK), hardware partners can perform the appropriate tests with their flash storage devices.

The STORAGE-0009 logo program requirement describes the details for “Enhanced for ReadyBoost” devices.

For more information on DTM, the WLK, and the Windows Logo Program, see “[Resources](#_Resources)” later in this paper.

# Windows ReadyDrive

ReadyDrive supports the use of hybrid hard disk drives (H‑HDDs) on systems running Windows Vista or later. An H-HDD combines a traditional hard disk drive with an integrated cache of nonvolatile flash memory (NV cache). The NV cache is used as:

* A high-performance cache for disk writes and low-latency reads.
* A storage area forSuperFetch.
* A cache for OEMs to store preferred blocks of data.

The NV cache increases responsiveness by avoiding the rotational and seek latencies of traditional hard disk drives (HDDs).

The NV cache also enables significant power savings. When the PC is running on battery, an H‑HDD can serve read/write requests from the NV cache and keep the disk spun down, reducing the drive’s power consumption. The disk spins up only when the write buffer is full, when a read request cannot be satisfied from the NV cache, or anytime an ATA flush command is issued.

The end user does not need to take any action to set up or maintain the contents of the NV cache. The nonvolatile memory content persists after power loss, and is flushed and refreshed opportunistically any time the traditional HDD needs to spin up. Table 4 shows a simplified logical profile of the usage of NV caches of various sizes.

Table 4. NV Cache Contents for Various Cache Sizes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample NV cache contents | 64 MB | 128 MB | 256 MB | 1 GB |
| H‑HDD firmware | ~10 MB | ~10 | ~10 | ~24 |
| Write cache:  ReadyDrive uses this space to buffer write requests and low-latency reads, which allows the disk to stay spun down longer and save power. | 32 MB | 32 | 32 | 32 |
| OEM cache:  PC OEMs can use this space to cache key data for quickly launching preferred user experiences and Windows HotStart™ experiences. | 1 MB | 1 MB + [(NV cache size - 100)/2] | | |
| SuperFetch cache:  SuperFetch uses this space to store data that enables it to maintain optimal memory content to support a given user’s usage patterns and to accelerate the boot and resume transitions. | Remainder | Remainder | Remainder | Remainder |

## Key Benefits

With dedicated areas for cached SuperFetch and OEM data, the integrated NV cache on an H‑HDD can improve system responsiveness in a variety of usage scenarios (see Table 5). The exact performance gains during any scenario depend largely on the details of the scenario, and the capacity and performance (data transfer rate) of the NV cache.

Table 5. Scenarios Where ReadyDrive Improves Performance

|  |  |
| --- | --- |
| Usage scenario | Performance improvement with ReadyDrive |
| System startup | The contents of the NV cache are nonvolatile and persist after power loss. When the system restarts, the cache still contains an optimal set of data to start the boot or resume process without waiting for the disk to spin up. |
| During heavy use (disk contention) | During heavy use, many programs are trying to access the disk contents. Windows can access frequently used programs and files in the NV cache without incurring any disk latency, resulting in more responsive user experiences. |
| PC OEM-specified experiences | PC manufacturers can use a dedicated section of the NV cache to cache key blocks of data for launching programs and other experiences without incurring disk latency. |
| Windows HotStart experiences | PC manufacturers can use a dedicated section of the NV cache to store files associated with Windows HotStart experiences. This caching enables faster and more consistent system startup directly into programs from keyboard commands. |

## Implementation Considerations

ReadyDrive is included in client editions of Windows Vista and later. ReadyDrive is enabled by default. Systems running Windows Vista and later automatically detect an H‑HDD and enable the ReadyDrive feature following the first boot. OEMs and users do not need to make any software or hardware modifications. A user can remove the H‑HDD from the system at any time without compromising the stored data.

Windows supports a maximum of one H‑HDD per PC. The H‑HDD can be installed in conjunction with, or as a replacement for, a standard Parallel ATA (PATA) or Serial ATA (SATA) mobile HDD. However, the H‑HDD must be configured as the system drive.

To achieve optimal power savings, we recommend that the computer have at least 1 GB of main memory to allow SuperFetch to minimize the number of read requests to the disk.

To optimize boot and resume-from-hibernate performance, the PC OEM should consider implementing a fast power-on self-test (POST) BIOS (<1 second) that passes execution to the operating system loader as quickly as possible.

Hybrid hard disk drive OEMs should follow these recommendations:

* Provide 256 MB to 1 GB of NV cache capacity; more is better.
* Implement wear-leveling algorithms to ensure longevity of the NV cache.

# PC Accelerators Requirements and Recommendations

Table 6 lists the requirements and recommendations for using PC Accelerators on systems running Windows Vista and later. For more information on Windows 7, see “[Windows 7 Improvements](#_Windows_7_Improvements)” later in this paper.

Table 6. PC Accelerators Requirements and Recommendations

|  |  |  |
| --- | --- | --- |
| Feature | Requirements | Recommendations |
| SuperFetch | None | For PC OEMs:   * As much main memory (RAM) as possible; at least 1 GB |
| ReadyBoot (Windows 7) | None | More than 1.7 GB of RAM if you want to avoid compressing data in the cache |
| ReadyBoost (Windows Vista) | For PC OEMs:   * USB host controllers must use USB 2.0 standard or higher   For flash storage OEMs:   * USB flash drives must use USB 2.0 standard or higher * USB flash drives must contain 230 MB of free capacity * Flash storage devices must perform at 2.5 MB/s for random 4-KB reads and 1.75 MB/s for random 512-KB writes * Cache sizes from 256 MB to 4 GB are supported   Additional requirements for flash storage devices “enhanced for ReadyBoost”:   * USB flash drives must contain 512 MB of physical flash; less is acceptable after formatting * Flash storage devices must perform at 5 MB/s for random 4-KB reads and 3 MB/s for random 512-KB writes | At least 2:1 ratio of ReadyBoost cache size to main memory capacity |
| ReadyBoost (Windows 7) | For PC OEMs:   * USB host controllers must use USB 2.0 standard or higher   For flash storage OEMs:   * USB flash drives must use USB 2.0 standard or higher * USB flash drives must contain 230 MB of free capacity * Flash storage devices must perform at 2.5 MB/s for random 4-KB reads and 1.75 MB/s for random 1-MB writes * Cache sizes from 256 MB to 32 GB are supported   Additional requirements for flash storage devices “enhanced for ReadyBoost”:   * USB flash drives must contain 512 MB of physical flash; less is acceptable after formatting * Flash storage devices must perform at 5 MB/s for random 4-KB reads and 3 MB/s for random 1-MB writes | At least 2:1 ratio of ReadyBoost cache size to main memory capacity |
| ReadyDrive | For hybrid hard disk OEMs:   * At least 50 MB of NV cache capacity * NV caches must perform at 4 MB/s for random 4-KB reads and writes, 16 MB/s for 64-KB sequential reads, 8 MB/s for 64-KB sequential writes | For PC OEMs:   * Fast POST BIOS (<1 second) * At least 1 GB of main memory (RAM)   For hybrid hard disk OEMs:   * 256 MB to 1 GB of NV cache capacity; more is better * Wear-leveling algorithms to ensure longevity of the NV cache |

# Windows 7 Improvements

The support for PC Accelerators in Windows 7 builds on the work done in Windows Vista. We refined the implementation based on extensive analysis of usage patterns and we tuned the policies to accommodate the increased variety of available storage devices. The following sections describe improvements in SuperFetch and ReadyBoost, and the introduction of ReadyBoot. There were no changes to ReadyDrive in Windows 7.

## SuperFetch Improvements

In Windows 7, SuperFetch still determines page priorities based on recent usage patterns, but it performs more selective prefetching. Windows 7 SuperFetch maintains only the highest priority pages in the ReadyBoost caches. We tested the improvements and confirmed that Windows 7 SuperFetch is more respectful of user presence, further decreasing prefetching while the user is active. These changes reduced SuperFetch’s memory footprint without affecting responsiveness.

Specific changes in Windows 7 SuperFetch include:

* Delay SuperFetch’s initial post-boot memory population by several minutes, contributing to the system’s post-boot quiet state.
* Better prioritize the private process pages of foreground applications to reduce hard faults from the pagefile.
* Significantly decrease prefetching for certain types of files that are now more efficiently retrieved from disk, such as:

Large and sequential files

MP3s, pictures, ISOs, and videos

Files that are only opened for write (such as log files)

* Track long-term memory pressure.

For systems that are memory constrained, prefetched pages can be quickly paged out before they are used unless they are both of highest priority and limited in size. By selectively prefetching on memory-constrained systems, SuperFetch reduces memory pressure while maintaining the highest-priority pages in memory.

We updated Windows 7 SuperFetch to accommodate new categories of storage, such as SSDs. The Windows PC Accelerators assume that reading from disk is relatively slow when compared to reading from cache. However, some new SSDs are fast enough that the incremental performance benefit of reading from cache is not worth the administrative overhead of maintaining the cache. If SuperFetch detects that the system drive is a fast SSD (as measured by Windows Experience Index Disk score), then SuperFetch turns off ReadyBoot, ReadyBoost, and the SuperFetch service itself.

**Caution:** We recommend that OEMs and users do not manually disable the SuperFetch service (Sysmain.dll). Disabling SuperFetch disables ReadyBoot and ReadyBoost and can decrease system responsiveness.

## ReadyBoot Improvements

ReadyBoot is a new feature in Windows 7.

If the system drive is a fast SSD, SuperFetch turns off the ReadyBoot feature.

## ReadyBoost Improvements

Windows 7 supports a maximum of eight ReadyBoost 32-GB caches per machine. These caches can be on a combination of internal and external ReadyBoost devices.

To create caches larger than 4 GB, format the ReadyBoost device (USB key, SD card, or other device) using exFAT or NTFS. We recommend using exFAT format for ReadyBoost devices.

Table 7 summarizes the Windows 7 ReadyBoost improvements.

Table 7. ReadyBoost Improvements in Windows 7

|  |  |  |
| --- | --- | --- |
| Improvement | Windows Vista maximum | Windows 7 maximum |
| More ReadyBoost caches | 1 per machine | 8 per machine |
| Bigger ReadyBoost caches | 4-GB cache size | 32 GB per cache |
| Encryption | 128-bit AES | 128-bit AES (default)  256-bit AES optional (set with Group Policy; global, per-machine setting) |
| Intelligent adaptation to hardware configurations |  | * Ongoing evaluation of cache response time (ETAs) to optimize retrieval times and load balance across caches and the disk * Compression is off for large caches on systems with slow CPUs * If the system disk is a fast SSD (as measured by Windows Experience Index Disk score), ReadyBoost is automatically turned off, because reading pages from the SSD should be quick * ReadyBoost does not cache data from secondary SSDs |
| Improved policies |  | Significantly decreased cache population when user is active |
| Preconfigured ReadyBoost devices | OEMs can indicate in the manifest that an internal device is a ReadyBoost device, and define the intended default size of the cache | OEMs can predefine multiple ReadyBoost devices and specify new options to define compression state and encryption state |

# Resources

#### Feature Team Contacts

For general or more technical inquiries about the Windows PC Accelerators, contact the feature teams directly:

* For ReadyBoost, ReadyBoot, and SuperFetch, contact [rbinfo@microsoft.com](mailto:rbinfo@microsoft.com)
* For ReadyDrive, contact [mshybrid@microsoft.com](mailto:mshybrid@microsoft.com)

#### Online Resources

ATA8-ACS Command Set

<http://www.t13.org/>

HDD manufacturers should consult the ATA8-ACS Command Set, which supports a command set for controlling the NV cache in an H‑HDD.

Driver Test Manager (DTM) and Windows Logo Kit (WLK)

<http://www.microsoft.com/whdc/winlogo/default.mspx>

By using Driver Test Manager (DTM) in the Windows Logo Kit (WLK), hardware partners can perform the appropriate tests with their H‑HDDs and flash storage devices.

Memory Sizing Guidance for Windows 7

<http://www.microsoft.com/whdc/system/hwdesign/memsizingwin7.mspx>

To take full advantage of the performance benefits created by SuperFetch, PCs should include as much main memory as needed to satisfy the expected workload.

Windows Driver Kit (WDK)

<http://www.microsoft.com/whdc/DevTools/WDK/default.mspx>

Windows Performance Monitor

<http://technet.microsoft.com/en-us/library/cc749249.aspx>

WinSAT

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