Intel® Cache Acceleration Software (Intel® CAS) for Windows* Workstation

Release 3.1

Administrator Guide

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Revision 1.5

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1 Introduction

1.1 Scope

This document offers the guidance to learn, install and begin using Intel® Cache Acceleration Software (Intel® CAS) for Windows* Workstation. This guide assumes a basic knowledge of storage and application management and Microsoft* Windows* Operating System.

1.2 Revision History

Document #	Description	Date
328330-001	Initial release.	December 2012
328330-002	Minor update for release 2.0.1	April 2013
328330-003	Major update for release 2.5	October 2013
328330-004	Minor update for release 2.5.1	April 2014
328330-005	Minor update for release 2.5.3	July 2014
328330-006	Major update for release 2.6.0	October 2014
328330-007	Minor update for release 2.6.1	December 2014
328330-008	Minor update for release 2.7	Febuary 2014
328330-009-10	Skipped these numbers to sync up with enterprise documentation	NA
328330-011	Minor update for release 3.0.1	February 2016
328330-012	Update for release 3.1	June 2016
328330-013	Minor Update to Admin guide	July 2017

1.3 Terminology

Term	Definition
cache	The storage media that can transparently store data and is typically faster than the primary storage so that future requests for that data can be served faster.
cache hit	When requested data is contained in (and returned from) the cache.
cache miss	When requested data is not in the cache, and therefore must be retrieved from its primary storage.
caching policy	A set of caching rules.
caching rule	A cache rule is one line in the “Include List” in the Intel® CAS GUI, which is used to specify which file/folder to be cached.
CAS	Short name for Intel Cache Acceleration Software.
CLI	Command Line Interface.
cold cache	At the moment cache is turned on, there is no data in cache yet. Initial IOs will be served out of primary storage. It takes some time for cache to warm up. Often used as opposite of warm cache.
cold data	Data is used least often. It is a relative-speaking term often used with warm data, hot data.

Term	Definition
DAS	Direct Attached Storage. A storage system directly attached to a server or workstation, without a storage network in between, mainly used to differentiate non-networked storage from SAN and NAS.
Dynamic cache mode switching	The ability to switch between cache modes while the cache is still running
dirty data	This refers to data that has latest copy in cache. The copy of the same data in primary storage is outdated.
Exclude list	Customize which files/folders not to be cached.
Guest OS	The operating system running on a Virtual Machine (VM).
host	The operating system running on the physical server, which hosts the Virtual Machines.
hot data	Data is used most often. It's a relative-speaking term. Often used with cold data, warm data. Ex: database journaling and file system metadata are often Hot Data.
hypervisor	A hypervisor is a piece of computer software, firmware or hardware that creates and runs Virtual Machines.
I/O blender	The I/O blender effect occurs when multiple virtual machines all send their I/O streams to a hypervisor for processing. Under heavy work loads, I/O processes which might otherwise have been relatively sequential, become random. This increases the read/write activity on disk heads, which in turn, increases latency.
I/O bottleneck	A term used to describe application slowdown due to the inability of storage subsystem to keep up with application demand.
IOPS	Input Output Per Second. The size of the IO package might be different from different vendors. Intel® CAS defaults to 4KB IO size.
latency	Same as response time. The measure of time delay from a requested I/O operation to its response.
LUN	Logical Unit Number. A number used to identify a device accessed by storage protocols which supports read/write operations (usually a logical disk). The term also refers to the disk itself.
NAND flash	The type of memory primarily used in today's flash cards and SSD drives, which is connected in a way that resembles a NAND (Negated AND) style circuit gate.
NAS	Network Attached Storage. File-level data storage (such as fixed disk and magnetic tape drives) that are directly linked to a storage area network or other network.
NTFS	New Technology File System. A proprietary file system that Microsoft developed for Windows* NT. NTFS supersedes the FAT file system as the preferred file system for Microsoft* Windows* operating systems.
NTFS Volume Mount Points	NTFS Volume Mount Points are specialized NTFS filesystem objects which are used to mount and provide an entry point to other volumes. Mount points can be created in a directory on an NTFS file system, which gives a reference to the root directory of the mounted volume.
over-provisioning	As it relates to primary storage, the allocation of additional physical disks to provide additional capacity to compensate for peak IO traffic.
Pass through	The caching mode in which the cache will be bypassed for all operations
primary storage	As it relates to caching, the primary storage typically refers to DAS, SAN, NAS, etc. where the data is stored before adding caching.
SAN	Storage Area Network. SAN is a dedicated network that provides access to consolidated, block level data storage, which appears as if it is attached locally to the operating system.
SSD	Solid-State Disk. A device used for data storage that uses non-volatile memory chips instead of a rotation disk.

Term	Definition
tiered storage	A data storage technique that moves data between two or more kinds of storage, which are differentiated by four primary attributes: price, performance, capacity, and function.
UNC	Uniform Naming Convention for Windows* network resources (such as a shared file, directory, or printer). The generic form for the "network path" is *ComputerName**SharedFolder**Resource*.
VM density	The measure of the number of virtual machines that can be supported per physical server. The greater the VM density, the less infrastructure required to support a given number of virtual applications, and therefore, less cost per application.
warm cache	The frequently used data has already been copied to cache, therefore subsequent IO likely will be served from cache instead of primary storage. Often used as opposite of cold cache.
warm data	Data is used more often than cold data, but less often than hot data. It is a relative-speaking term. Often used with cold data, hot data.
write-around	A write caching mode in which some write operations are not cached. Writes to blocks that do not exist in cache are written directly to the core device, bypassing the cache. If a write operation is issued to a block that is already in cache (because of a previous read operation), then writes are sent to both the core device the cache device. Write-Around cache improves performance of workloads where write operations are done rarely and no further read accesses to that data are performed, so there is no benefit in caching it.
write-back	A write caching policy where data is written initially to the cache only and then written to primary storage later. As result, it is possible that the data in cache and primary storage might be out of sync before the latest data in cache is flushed (written) to primary storage.
write-through	A write caching policy where every write to the cache causes a synchronous write to primary storage. As result, the data in cache is always the same as in primary storage.

1.4 References

The following resources and tools are suggested for assisting with Intel® CAS testing and benchmarking.

Table 1-1 Reference Documents

Name	Purpose	To Learn More
Windows* System Monitor	Monitor system cpu, memory and disk usage and activities.	*https://msdn.microsoft.com/en-us/library/ms191246.aspx*
Windows* Performance Monitor	Check out built-in Windows performance counters and Intel® CAS performance counters.	http://technet.microsoft.com/en-us/library/cc771692%28WS.10%29.aspx#BKMK_Scen2
IOMeter*	A Synthetic IO benchmark tool	http://www.iometer.org
Sysbench*	To benchmark MySql database	http://dev.mysql.com/downloads/benchmarks.html
PCMark8*	Benchmark tool for storage	http://www.futuremark.com/benchmarks/pcmark
SPECwpc*	Workstation Performance Characterization Benchmarking	http://www.spec.org/gwpg/wpc.static/wpc_overview.html

2 Product Overview

2.1 What is Intel® CAS

Intel® CAS accelerates Microsoft* Windows* applications by caching most often used, i.e. hot data, to a local flash device inside servers and virtual machines. Intel® CAS implements caching at the server side, which means caching flash device is installed inside the application server as close as possible to the CPU, thus reducing storage latency introduced by SAN or NAS.

Intel® CAS is a Windows* filter driver, working coherently with the operation system and device driver. The caching solution is transparent to users, VMs, applications, and existing storage infrastructure. No storage migration or application modification is required.

Intel® CAS offers both write-back and write-through cache modes. It employs a block-based caching architecture that provides greater granularity for caching management, while providing file-level caching policy, which allows you to conveniently customize cache for your own applications.

2.2 Supported Platforms

Table 2-1 Supported Platforms

Platform	Notes
Windows* 8.1	64-bit only
Windows* 10	64-bit only
Hyper-V	Can be installed in host and guest OS where guest OS is one of the supported OS

2.3 System Requirements

Table 2-2 Intel® CAS system requirements

Memory	2% of caching capacity
Supported flash/SSD	Any SATA, SAS, PCIe flash device larger than 5 GB and smaller than 16TB The following Intel® SSDs have been fully validated: • Intel® SSD P3700 • Intel® SSD S3700, S3500 • Intel® SSD Pro 2500 Series • Intel® SSD 750 Series
Supported storage	DAS, SAN, and limited NAS.
Application Requirement	.NET framework preinstalled with the OS: • 4.5.1 for Windows 8.1 • 4.6 for Windows 10 Microsoft Visual C++ 2012 Redistributable Package: Will be installed by Intel® CAS installer if missing.

2.4 What's New in This Release

2.4.1 New Features

- Dynamic cache mode switching
  - Allows users to dynamically change cache modes while the cache is still running.
- Write-around Caching (see Configuring with the GUI)
  - A write caching mode in which some write operations are not cached. Writes to blocks that do not exist in cache are written directly to the core device, bypassing the cache. If a write operation is issued to a block that is already in cache (because of a previous read operation), then writes are sent to both the core device the cache device. Write-Around cache improves performance of workloads where write operations are done rarely and no further read accesses to that data are performed, so there is no benefit in caching it.
- Pass-through Caching (see Configuring with the GUI)
  - A caching mode in which the software will bypass the cache for all operations. This allows the user to associate all their desired core devices to be cached prior to actually enabling caching. Once the core devices are associated, the user would dynamically switch to their desired caching mode.
- Exclude list (see Configuring with the GUI)
  - This is the list of files that are selected to not be cached. You can customize which files/folders are not to be cached by customizing the exclude list

2.4.2 Updates to Existing Features

- **Warm cache after dirty shutdown**

  This release expands the warm cache functionality. Previously cache was warn only when OS started after a clean (planned) shutdown. Starting with this version cache is also warm after a dirty shutdown (power failure, BSOD, etc.). In that case cache will be rebuilt only based on dirty data (data which were not synchronized between SSD and HDD in write back mode) and, this works for write back mode only (or for a case when cache mode was switched from write back mode to another without flushing dirty data). All data which were marked as cleaned will not be in cache after such OS starts.

2.5 Limitations

- Maximum number of caching rules shall not exceed 65000.
- Maximum number of cached files shall not exceed 65000 files. If the 65000 up limit is reached, the least used file will be evicted in order to cache new file.
- If the data in primary storage is encrypted, we suggest same level of protection for data in caching SSD. Since we do not support software encryption, we suggest using Opal compliant Intel® SSDs to enable hardware encryption for both caching SSD and primary storage.
- Does not support software encryption/compression for the data in cache and the corresponding data in primary storage.
- Does not support Alternate Data Streams.
- Does not support Transactional NTFS (TxF).
- Only files larger than or equal to 4KB will be cached.

- Only limited NAS use cases are supported. For more details, see ***NAS***.
- Intel® CAS only provides software upgrade, not downgrade. User can uninstall the newer release, then install the older release if have to.
- Only one instance of Intel® CAS application can be running at any given time.
- VMware limitation – Requires Advanced Options to setup virtual disk as cache
    - Virtual disks will not be recognized as suitable for caching by Intel® CAS Drive setup wizard
    - Choose Advanced menu to configure the virtual disk as cache
- Microsoft* Windows System Restore and Windows Backup limitations:
    - ***Intel® CAS must be stopped prior to performing a system restore or backup:***
        - Open the Intel® CAS Acceleration Software GUI, select the “Stop Cache” Button.
        - After System Restore is complete, open GUI, select the “Start Cache” Button.
- Microsoft* Windows Server 2008 R2 – OS support for SHA-2 Certificates is required to install Intel® CAS beginning January 1, 2016
    - If Microsoft* Windows Update is enabled no user intervention is required.
    - If Internet access is enabled, the Intel® CAS application will dynamically install the necessary patch and no user intervention is required
    - On platforms that do meet the above conditions, the Intel® CAS application will inform users to manually install the patch KB3033929 to enable OS support for SHA-2 certificates.
    - Please see Instructions in Appendix A.1 section for manually installing KB3033929
- Intel® CAS Support policy for 4K Sector drives
    - Intel® CAS does not support 4K native (4K logical sector size) drives.
    - Intel® CAS supports the physical format of drives that are 512-byte logical sectors.

3 Getting Started

3.1 Prepare Caching SSD

First make sure the SSD capacity meet min and max requirement (see System Requirements section).
Make sure to install latest driver from the vendor for the caching SSD.
Web Link for Intel® Solid State drives:

http://www.intel.com/content/www/us/en/support/solid-state-drives.html

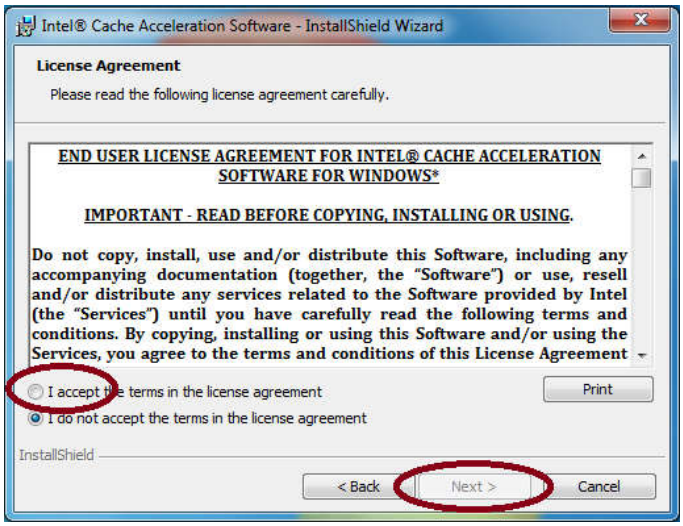
If there is no usable data on the SSD, leave the SSD as raw device. If there is usable data on the SSD and the remaining capacity still meets minimum and maximum requirements, Intel® CAS provides a setup wizard to guide you through creating dedicated partition for caching.

3.2 Installing Intel® CAS

3.2.1 Using the Installer

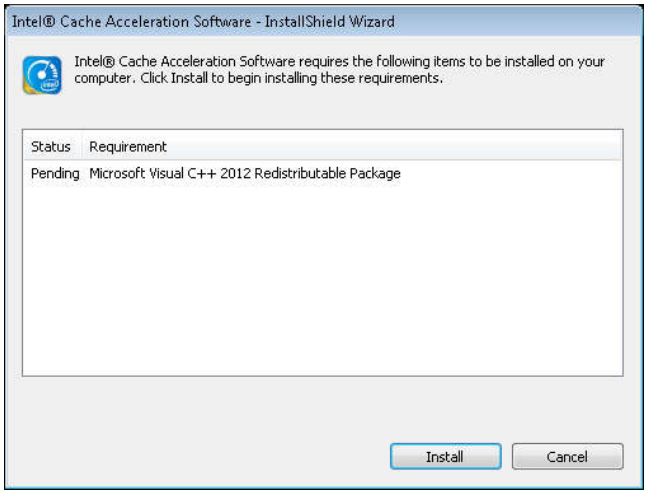
Run installer IntelCacheAccelerationSoftware_x64-x.x.x.x.exe * with administrator rights.

1. At the Welcome screen, click **Next**.
2. At the License Agreement screen, click the *I accept the terms of the license agreement* option and click **Next**.



If Microsoft Visual C++ Distributable Package hasn't been installed on the system yet, INTEL® CAS installer

will install it.



3. At the Destination Folder screen, you can change default installation folder, or click **Next** to continue.
4. At the Ready to Install the Program screen, click **Install**.
5. At the InstallShield Wizard Completed screen, click **Finish**.

3.2.2 Using the Command Line

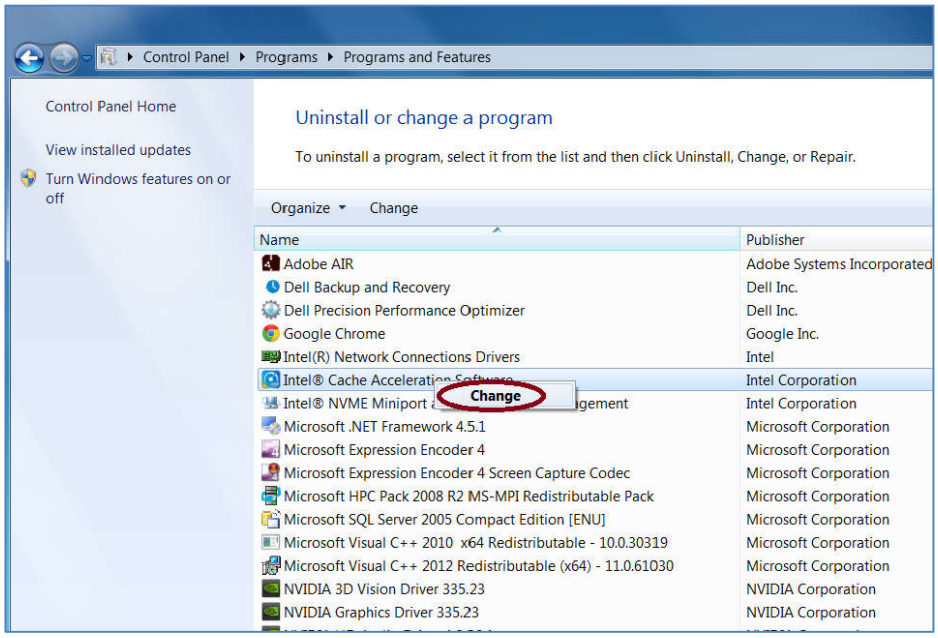
You can install Intel® CAS from command line in silent mode. Open a command window with administrator right, change to the directory where Intel® CAS installer is saved. Type following command line:

```
C:>IntelCacheAccelerationSoftware_x64-
x.x.x.xxxx.exe /S /v" /qn INSTALLDIR=\"C:\\Program Files\\Intel\\Cache Accele
ration Software\\\" REBOOT=\"ReallySuppress\""
```

3.3 Uninstalling Intel® CAS

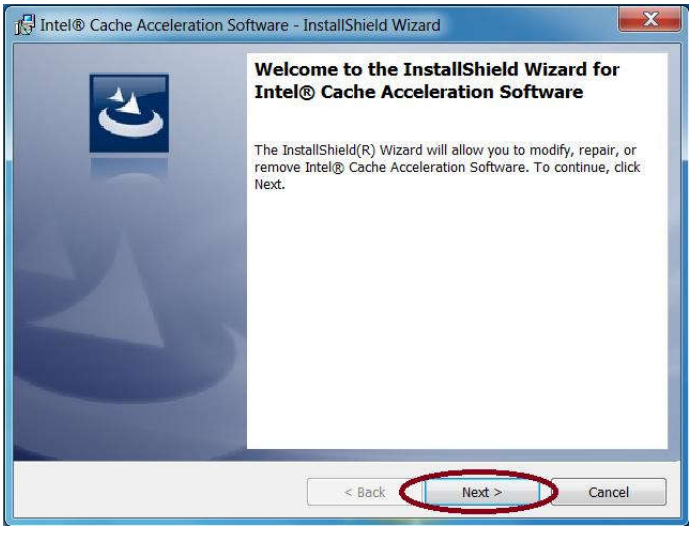
3.3.1 Uninstalling from the Control Panel

1. Go to Control Panel, Right click *Intel® Cache Acceleration Software* and choose *Change.*

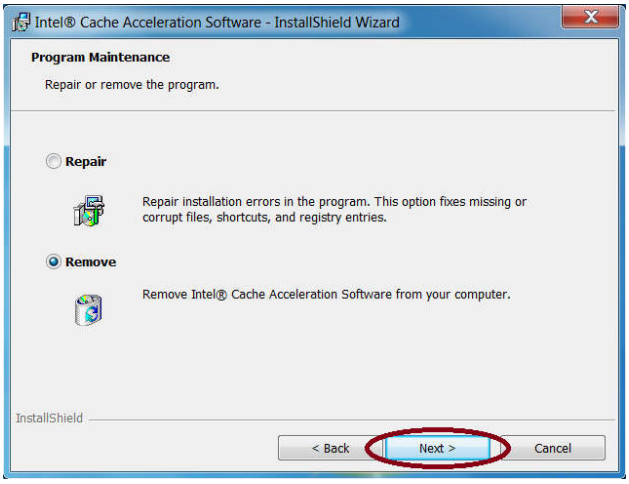


This opens the Intel® InstallShield, which can repair or remove Intel® CAS as well.

2. Click **Next**.

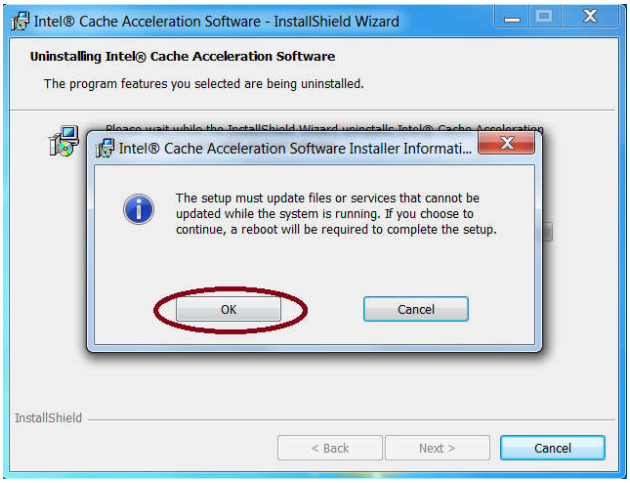


3. At the Program Maintenance screen, choose to remove Intel® CAS and click **Next**.



4. At the InstallShield Wizard Completed screen, click **Finish**.

   Normal uninstall should not requires reboot. But if inconsistency information is found, a reboot will be required to clean up the situation.



3.3.2 Using the Command Line

Use the WMIC (Windows Management Instrumentation Command-line) or from command line prompt (CMD.exe) with a filter "name like '%%Cache Acceleration Software%%'" to uninstall.

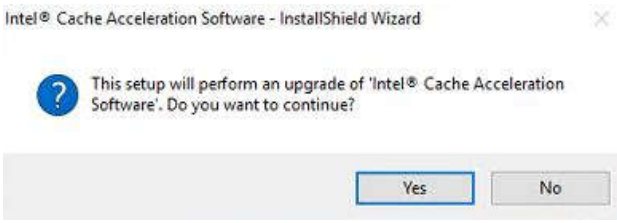
3.4 Upgrading to a Newer Release

You can upgrade to newer release without uninstalling older release. The installer will automatically uninstall the older release. We recommend stopping the cache before upgrading.

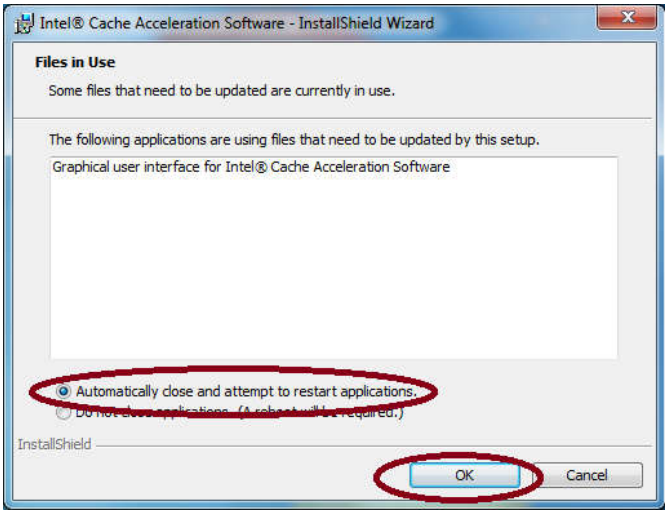
Assuming no change on caching SSD, the old configuration (caching SSD partition, caching mode, include list) will be kept after upgrade. Caching will be stopped during upgrade.

Run *IntelCacheAccelerationSoftware_x64-x.x.x.xxxx.exe* with administrator right to start upgrade. Upgrade process will be similar to install process, except following a few extra screens.

- Intel® CAS detected an older release, are you sure you want to proceed?



- Some components related with Intel® CAS are running in background, for instance GUI, CLI, Service, therefore a warning message like this is expected.



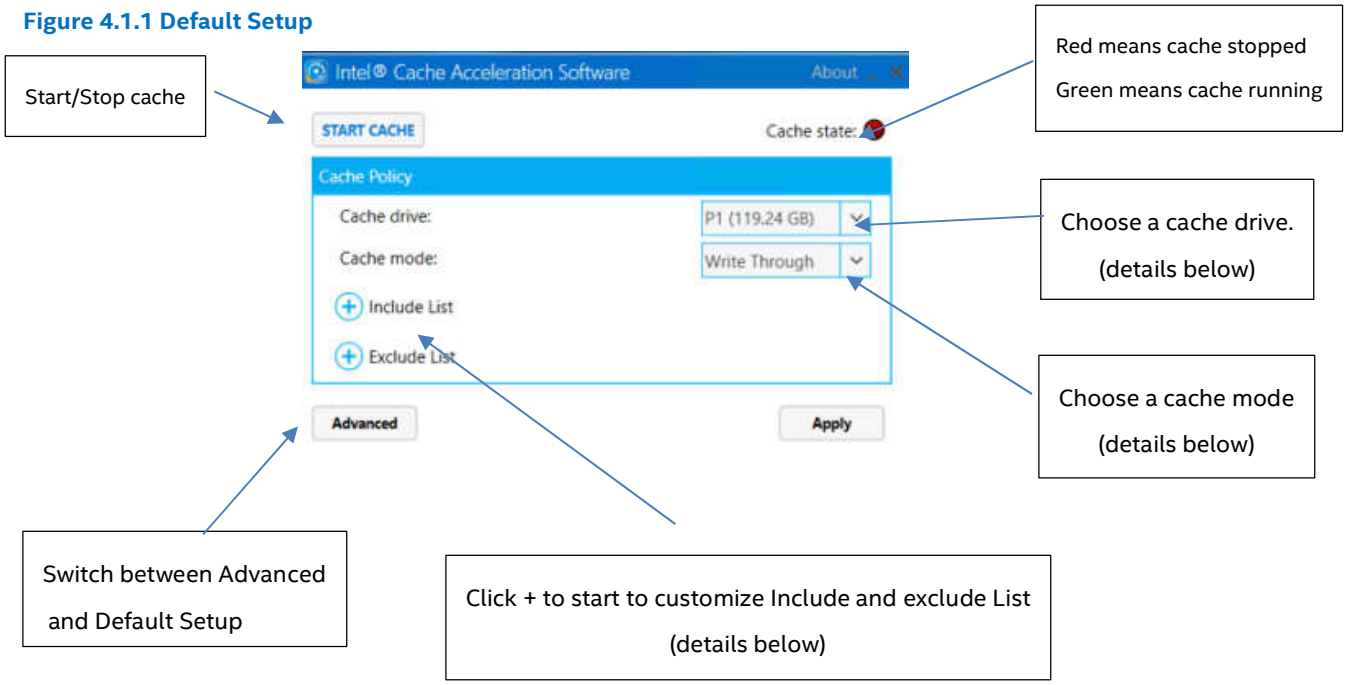
3.5 Known Issues

Reference	Description	Solution
CAS-W-91714	When limit of 65000 cached files in some cases new files are not added to cache.	Fixed
CAS-W-91966	CAS cannot be uninstalled through Apps & features on Windows 10.	Fixed
CAS-W-93680	CAS Service must be sometimes manually started after OS boot.	Fixed

4 Configuring Intel® CAS

4.1 Configuring with the GUI

Figure 4.1.1 Default Setup



- **Cache Drive**

  If you are going to use the whole SSD as the caching drive, you can choose it from the drop down list. If you are going to use partial SSD as caching, you will have to create a partition from the SSD, which can only be done in the Advanced Setup.

- **Cache Mode**

  All modes, write-through, write-back, write-around and pass-through modes are supported.

	Write-through	Write-back	Write-around	Pass-through
Definition	Every data is written to both cache device and primary storage. As result, the data in cache device is always in sync with data in primary storage	Data is only written to cache device at first. Later on, the data is flushed, i.e. written, to primary storage.	A caching mode in which some write operations are not cached. Writes to blocks that do not exist in cache are written directly to the core device, bypassing the cache.	Allows users to dynamically change cache modes while the cache is running.

Advantage	Every data has two copies, one in cache device and the other in primary storage.	Write performance is as fast as cache device write performance.	Improves performance of workloads where write operations are done rarely and no further read accesses to that data are performed, so there is no benefit in caching it.	Dynamically switching to pass-through mode is useful in preventing cache pollution when the system is undergoing maintenance operations, for example.
Disadvantage	The write performance is bottlenecked by primary storage write performance.	The dirty data has only one copy of data in cache device.	A read request for recently written data will create a "cache miss" and have to be read from the primary storage and experience higher latency.	Data is not cached

- **Include List**

  You can customize which files/folders to be cached by customizing the include list.

  You can either "Include" or "Pin". The difference is:

	Include	**Pin**
Guaranteed?	Best Effort, The cache will make best effort to promote the data to cache	Ensure The cache will ensure that the pinned data shall be promoted in cache and remain in cache
When?	First access of the file	Immediately
What?	Files and folders	Files only
Why?	Narrow the caching target to the identified files/folders	Warm the cache in advance, and avoid eviction of the identified files

Figure 4.1.2 Include List

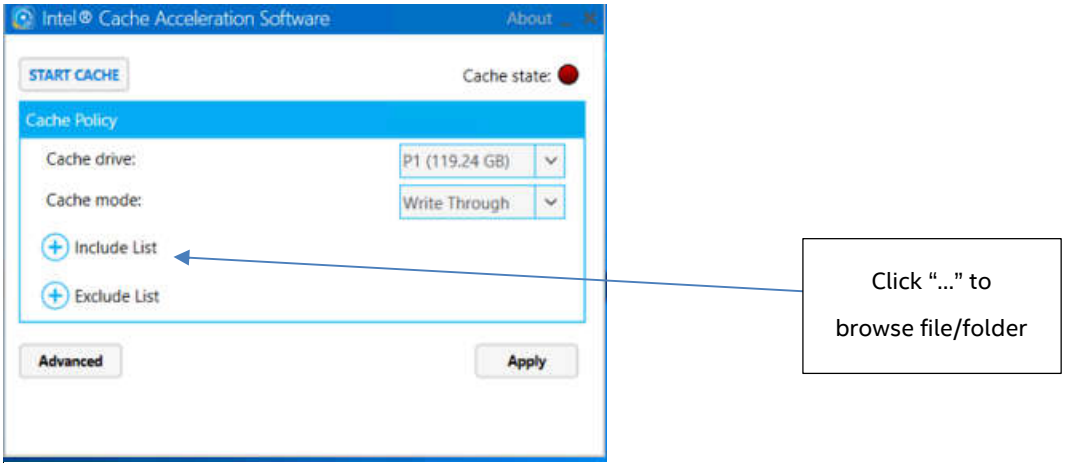


Figure 4.1.3 Browse File

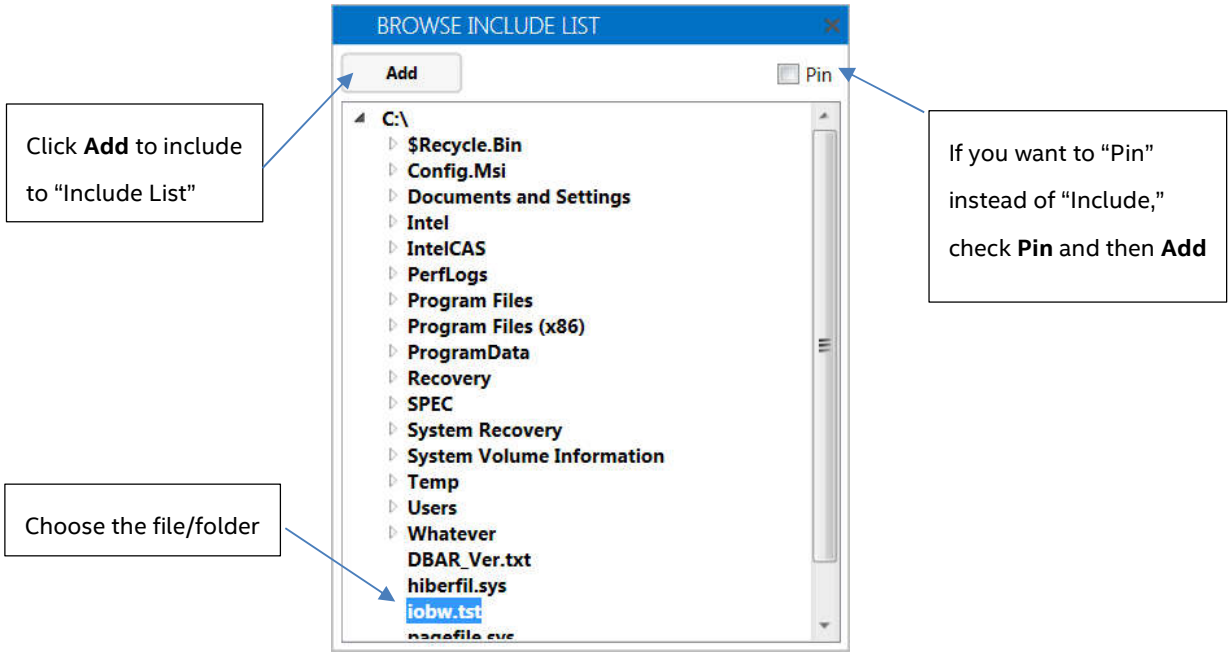
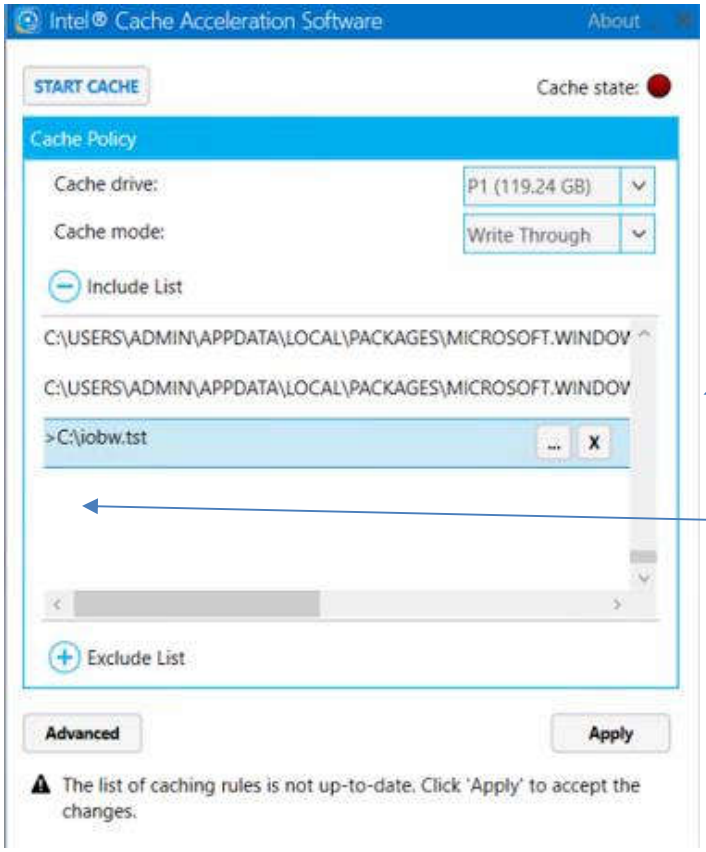


Figure 4.1.4 Finish a Cache Rule



This is how it looks after you "include" a file.

This is how it looks after you "Pin" a file. Note the "**>**" sign in front of it.

Cache rule

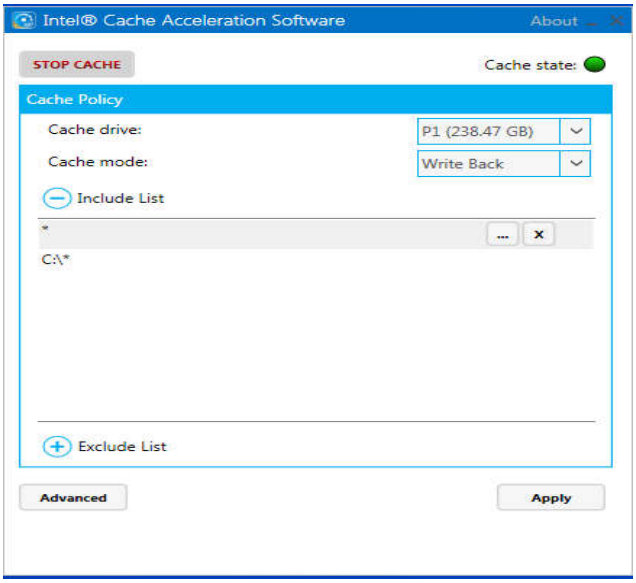
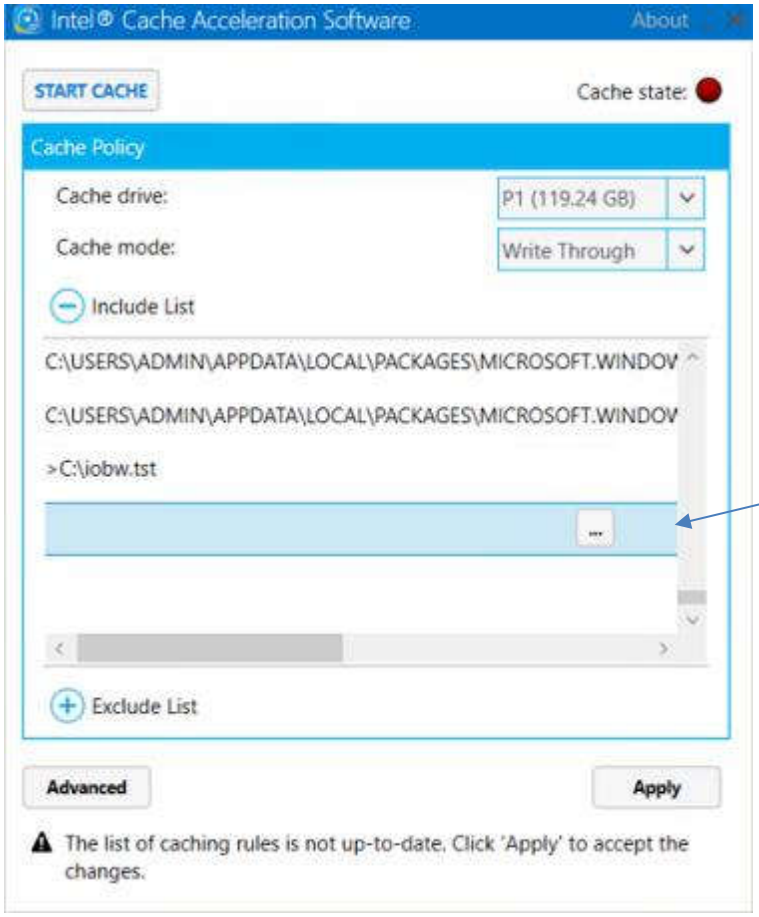
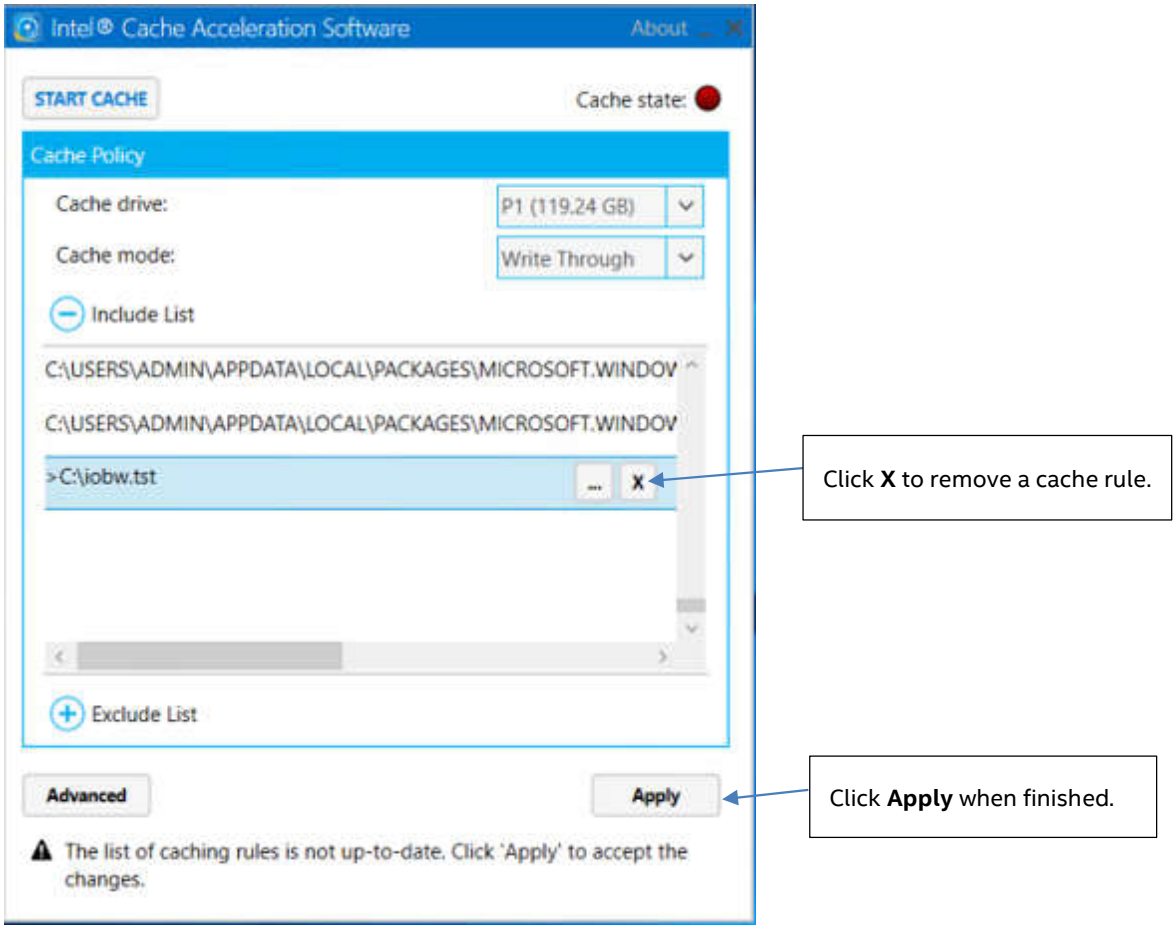


Figure 4.1.5 Add Multiple Cache Rules



Click the open space below the previous cache rule to add one more cache rule.

Figure 4.1.6 Remove a Cache Rule



- **Exclude List**

  You can customize which files/folders not to be cached by customizing the exclude list.

Figure 4.1.7 Exclude list

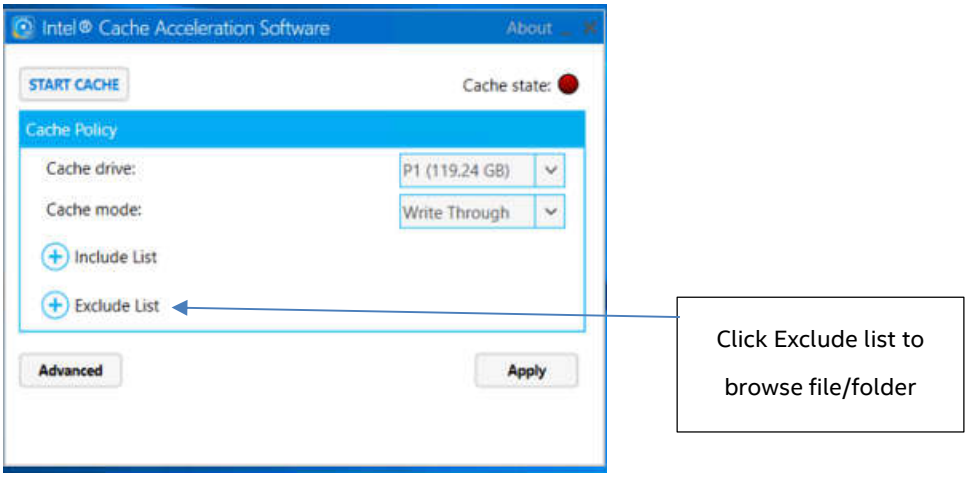


Figure 4.1.8 Exclude list

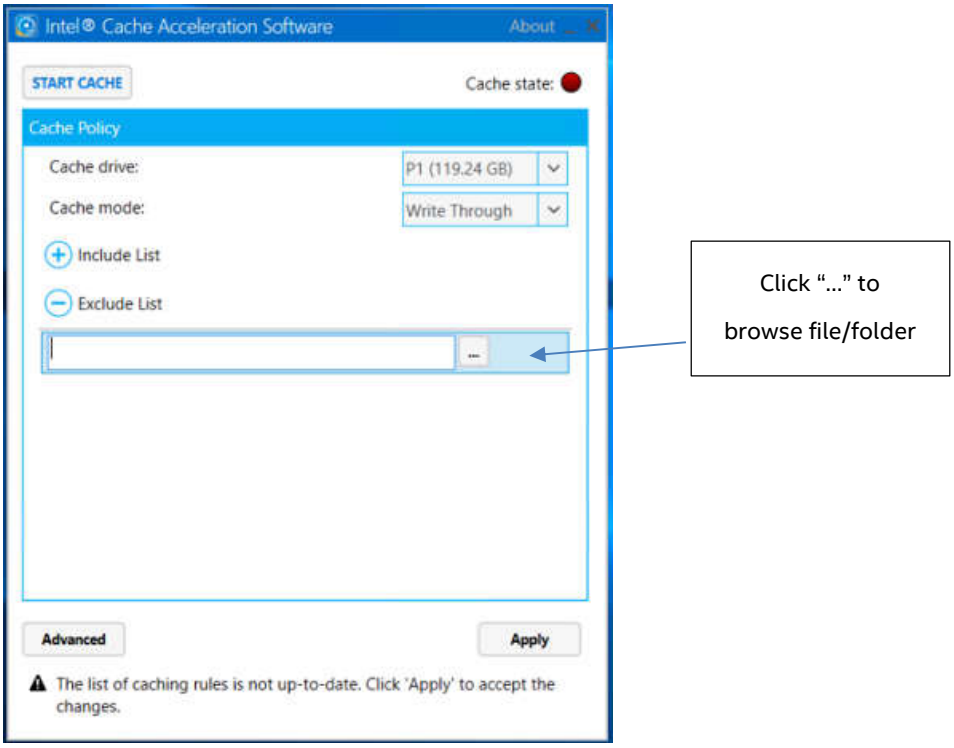


Figure 4.1.9 Exclude list

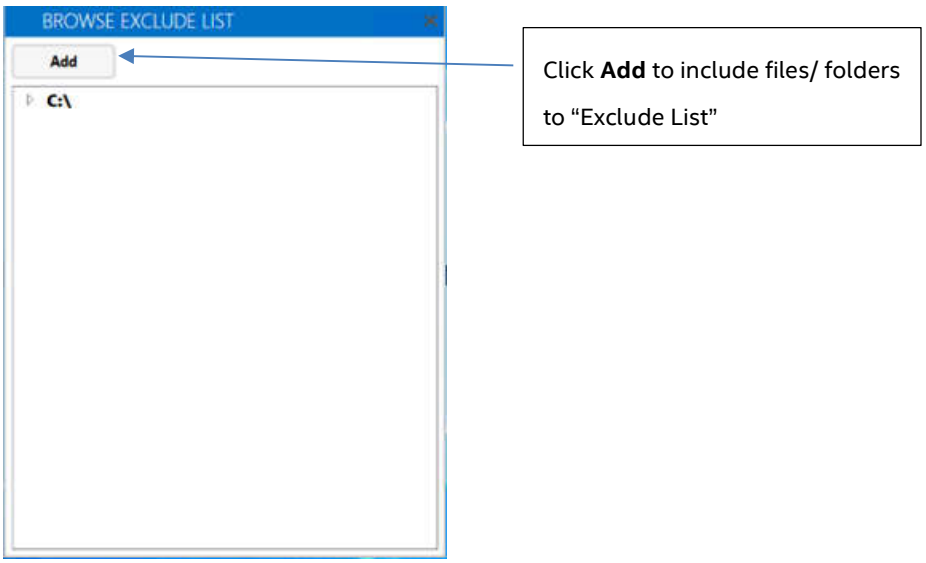
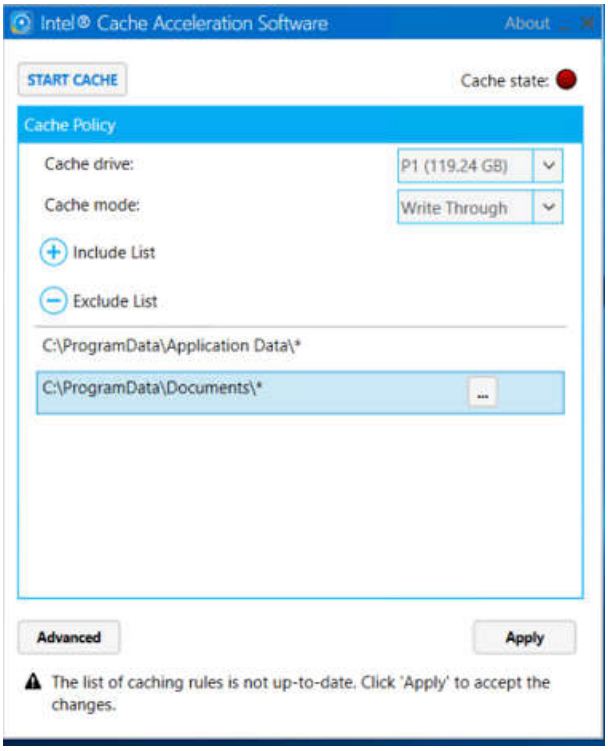


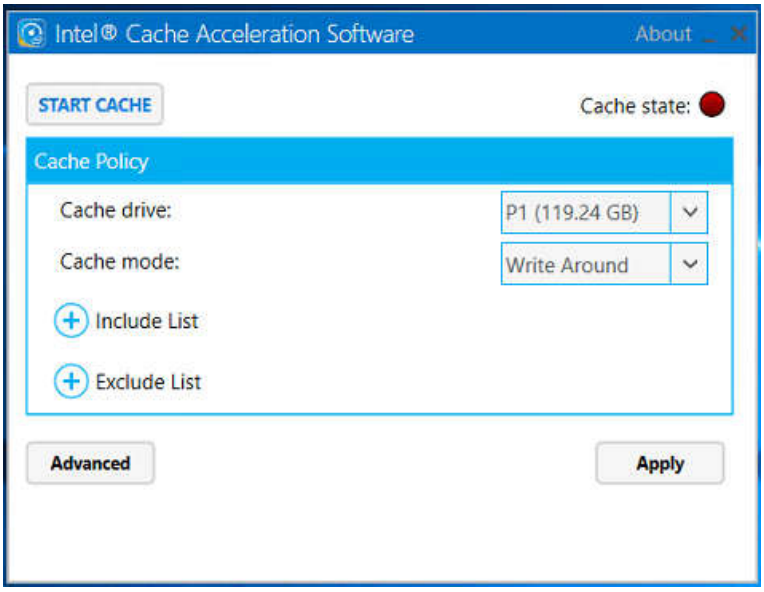
Figure 4.1.10 Exclude list



- Write-Around Caching mode

  In write-around mode, the caching software writes data to the flash device if and only if that block already exists in the cache and simultaneously writes the same data “through” to the core device (disk drives). Write-around is similar to write-through in that it ensures the core device is 100% in sync with the cache and in that this type of cache will accelerate only read intensive operations. However, write-around further optimizes the cache to avoid cache pollution in cases where data is written and not often subsequently re-read.

  Figure 4.1.11 Write-around caching mode



- Pass-through mode

Allows users to dynamically change cache modes while the cache is running. In pass-through mode, the caching software will bypass the cache for all operations. This allows the user to associate all their desired core devices to be cached prior to actually enabling caching. Once the core devices are associated, the user would dynamically switch to their desired caching mode.

Figure 4.1.12 Pass-through caching mode

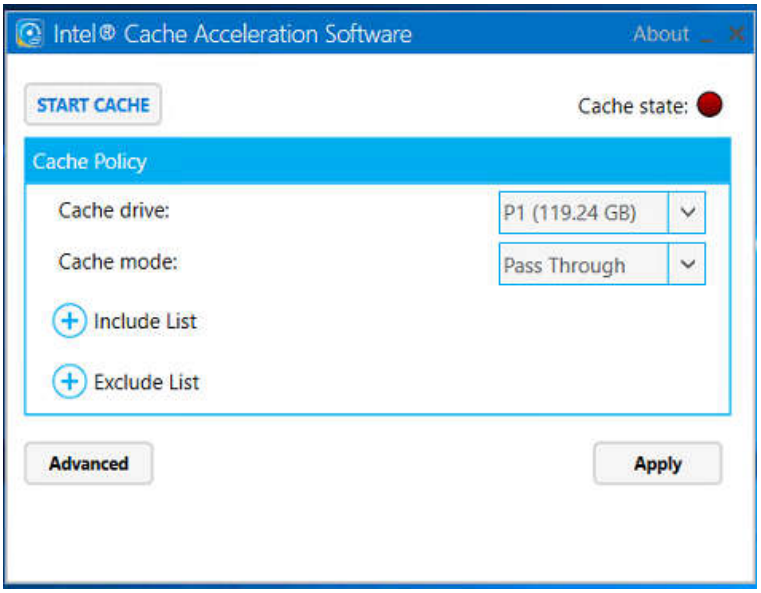


Figure 4.1.13 Advanced Options

Figure 4.1.13 Advanced Options

If the SSD has file system on it already, use **Format drive** to reformat the SSD to become eligible as caching SSD again.

If there is free space on the SSD and you'd like to use the free space as caching, choose **Use free space**.

If you would like to reuse an existing partition as caching, choose **Replace existing partition**.

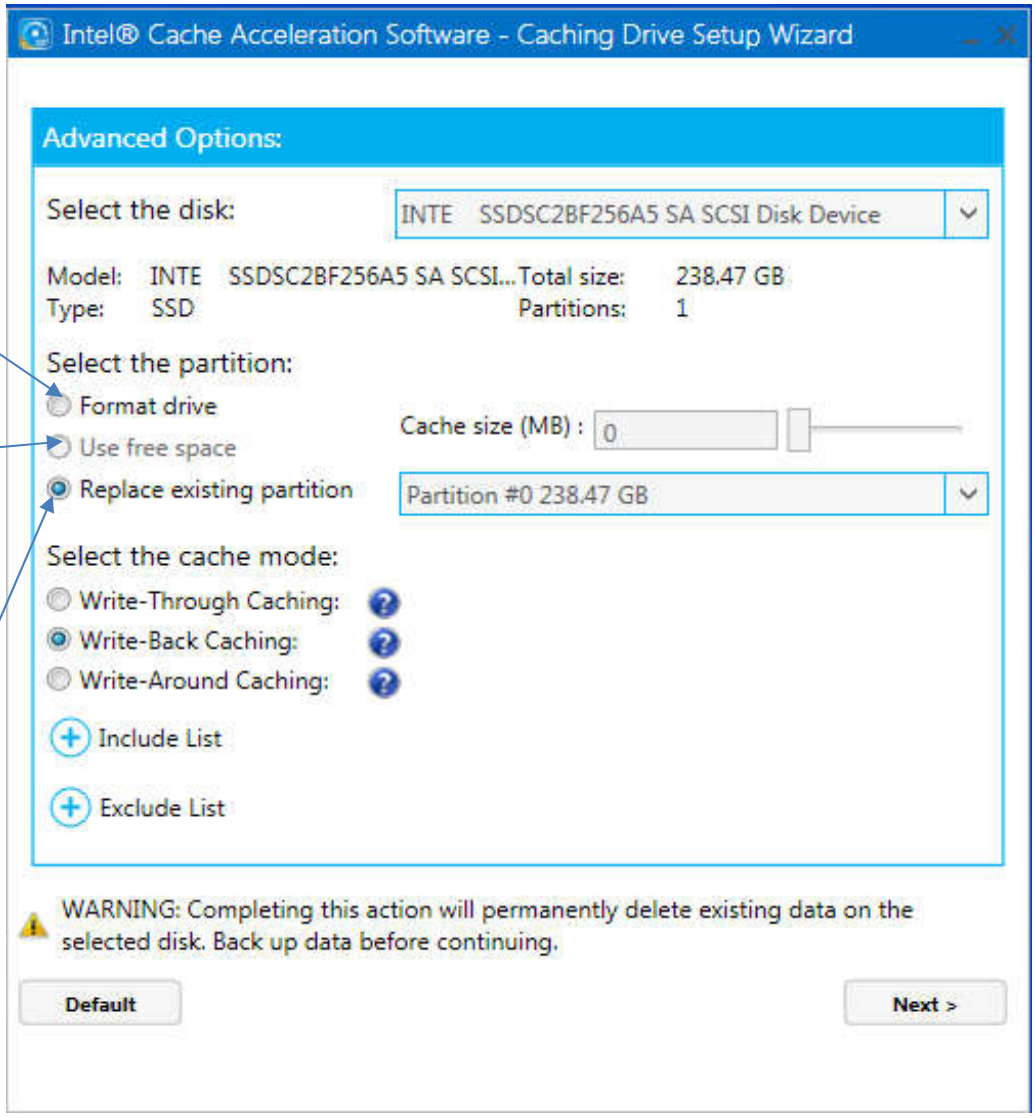
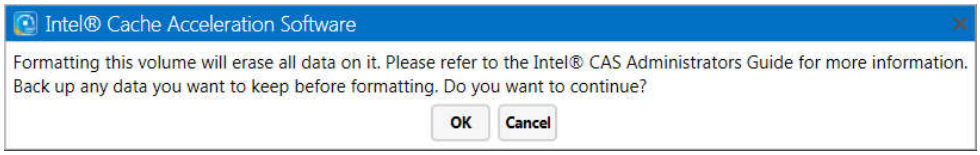
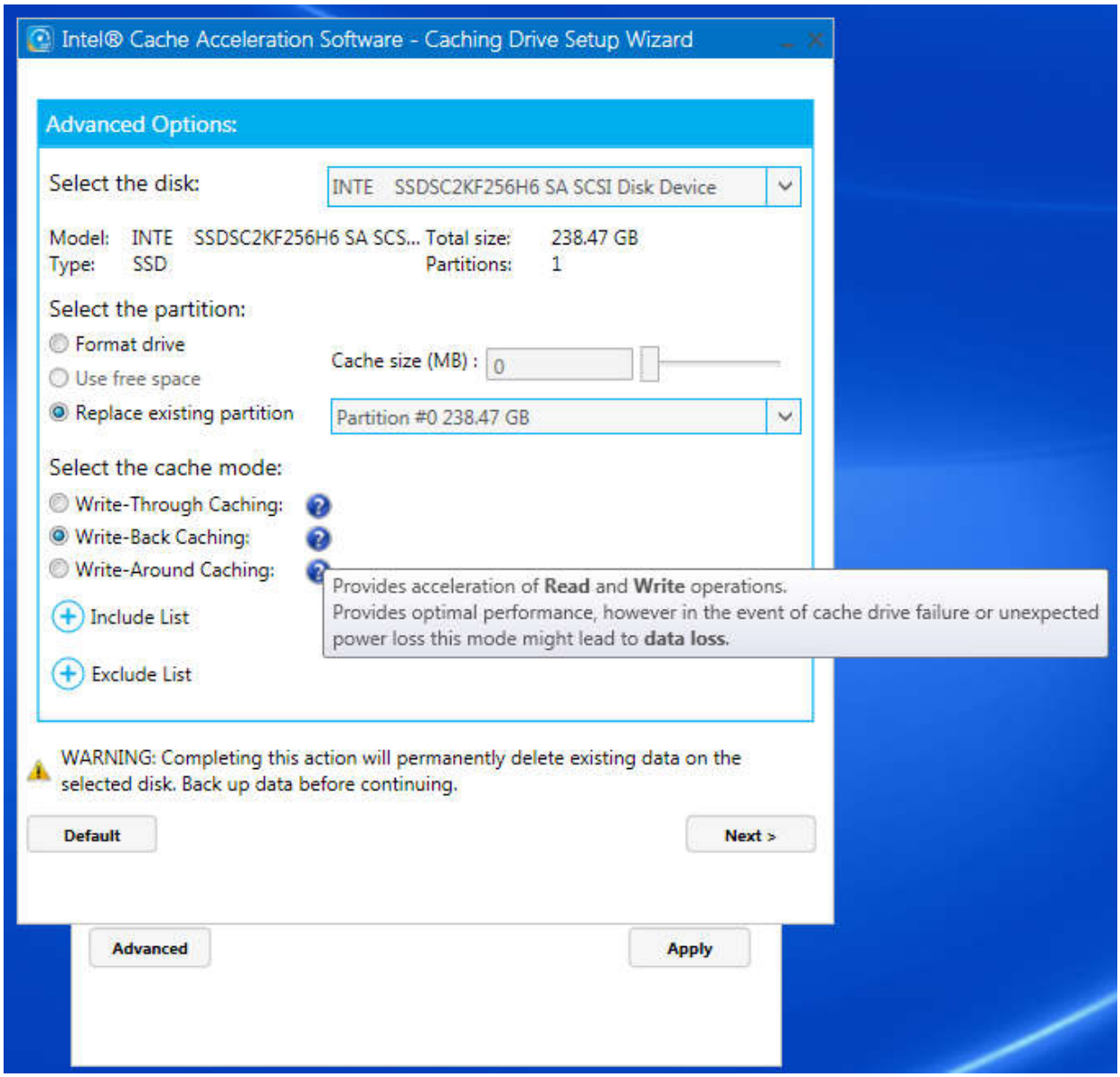


Figure 4.1.14 Confirmation





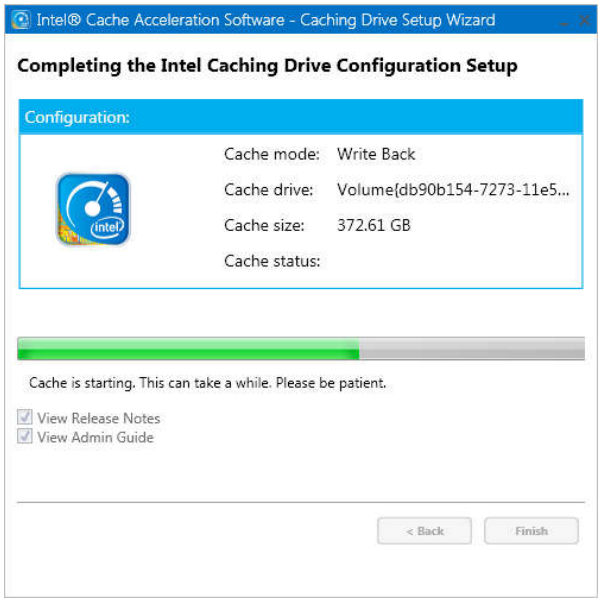
NOTE: Write-back Caching Mode:

By default the Caching mode is selected to the "**Write Through**" mode. A write caching policy where every write to the cache causes a synchronous write to primary storage. As result, the data in cache is always the same as in primary storage.

Caching modes can be modified by selecting the radio button.

- **Write-Back Caching:**
  Note: *Write-back caching provides acceleration of Read and Write operations as data is written to the cache initially and then written to primary storage. Write-back caching delivers optimal performance, however in the event of a cache drive failure or unexpected power loss Write-back might lead to data loss. Using Write-through caching mode or implementing a RAID volume on the caching drive is recommended.*

Figure 4.1.16 Wait for Setup to Complete



4.2 Configuring with CLI

Intel® CAS also provides command interface to assist scripting of setup and modification of configuration. Administrator privilege is required to use Intel® CAS CLI.

To start CLI, open a command window as Administrator. Change to following path. Then run *IntelCASCLI.exe* with valid command options.

Use –H after the command to learn detailed instruction. For example:

C:\Program Files\Intel\Cache Acceleration Software\IntelCASCLI.exe –S -H

NOTE: Adjust accordingly if using different installation folder.

The available command options are:

Command (short)	Command (long)	Description
-S	--start-cache	Start new cache instance or load using metadata
-T	--stop-cache	Stop cache instance
-Q	--set-cache-mode	Set cache mode
-A	--add-rule	Add new caching rule to cache instance
-R	--remove-rules	Remove caching rules
-L	--list-caches	List all cache instances
-P	--stats	Print statistics for cache instance
-Z	--reset-stats	Reset cache statistics
-X	--list-rules	List all caching rules
-F	--flush-cache	Flush all dirty data from the caching device to core devices
-V	--version	Prints Intel Cache Acceleration Software version
-N	--set-NAS-support	Enable/disable NAS support Valid command line options: --set-NAS-support –N -m –mode<MODE> ON/OFF Ex: “IntelCASCLI.exe –-set-NAS-support –-mode ON” OR “IntelCASCLI.exe –N –m ON”
-H	--help	Give this help list

4.3 Modifying the Configuration While the Cache is Running

You are not required to stop caching to modify the configuration. However, certain modifications will cause the cache to restart from cold cache.

The following modifications will NOT cause caching to restart from cold cache:

- Adding/removing/modifying a cache rule.

The following modifications will cause caching to restart from cold cache:

- Changing caching from one SSD to another.
- Changing caching from one partition to another on the same SSD.

5 Use Intel® CAS with SAN or NAS

5.1 SAN

SAN by nature is a block device, therefore you can use Intel® CAS with SAN pretty much the same as if it were DAS. The only thing special is that SAN can be connected through a drive letter or NTFS Volume Mount Point.

- SAN attached storage using a drive letter is included the same way as if it were DAS.
- SAN attached storage using NTFS Volume Mount Point is included the same way as if it were a local folder.

5.2 NAS

- Intel® CAS can also support NAS for following two use cases. Any other use cases are not supported.

  Use Case1: Caching of NAS-based files with Read-Only Permission (If the file needs to be updated, turn off the caching on all installed machines, update the file, and turn on caching again.)

  Use Case2: Caching of NAS-based files with Read/Write Permissions, but only a single machine (physical or virtual) that writes the file can be configured to cache the file. Other non-caching machines can only read the file.

  WARNING: *Turning on NAS support for use cases other than the two Use Cases identified above could result in data loss or data corruption.*

- NAS devices must have static IPs assigned to them. Dynamically assigned IPs are not allowed.
- "Pinning" files from NAS is not supported. Only "include" files from NAS is supported.
- Only write-through mode is available for caching NAS.
- NAS support is turned off by default. If you are using one of the above identified two use cases, you can turn it on by doing following:
  - If using 3.1 or newer releases:

    Use CLI to enable/disable NAS support. (See Configuring with CLI)

- NAS attached storage is included in the form \\IP address\Folder Name\...

  or \\DNS\Folder Name\...

  You can type this syntax in the cache rule box in the Intel® CAS GUI.

6 Monitoring the Cache

6.1 Available Cache Statistics

Intel® CAS provides many statistics about cache. The basic and extended statistics available are shown in the following tables.

Table 6-1 Intel® CAS – Basic Statistics

% Cache Read Hits/sec	Percentage of cache read hits per second
% Cache Read Misses/sec	Percentage of cache read misses per second
% Cache Write Hits/sec	Percentage of cache write hits per second
% Cache Write Misses/sec	Percentage of cache write misses per second
% Cumulative Cache Read Hits	Percentage of total cache read hits
% Cumulative Cache Read Misses	Percentage of total cache read miss
% Cumulative Cache Write Hits	Percentage of total cache write hits
% Cumulative Cache Write Misses	Percentage of total cache write misses
Cache Read hits/sec	Number of read hits per second
Cache Read misses/sec	Number of reads missed per second
Cache Write hits/sec	Number of write hits per second
Cache Write misses/sec	Number of write missed per second
MB Active Cache Size	Total Active Cache size in MB. The amount of data in the cache device.
MB Cache Cleaned	Total dirty data cleaned in MB
MB Cache Cleaned/sec	Dirty data cleaned in MB per sec
MB Cache Freed	Total data evicted from cache in MB
MB Cache Freed/sec	Data evicted from cache in MB per second
MB Cache Read Hits	Total cache read hits in MB
MB Cache Read Hits/sec	Cache read hits in MB per second
MB Cache Read Misses	Total cache read missed in MB
MB Cache Read Misses/sec	Cache read missed in MB per second
MB Cache Write Hits	Total cache write hits in MB
MB Cache Write Hits/sec	Cache write hits in MB per second
MB Cache Write Misses	Total cache write missed in MB
MB Cache Write Misses/sec	Cache write missed in MB per second
Reads	Total Number of read
Reads/sec	Number of read per second
Writes	Total Number of write
Writes/sec	Number of write per second
MB Reads	Total MB of read

MB Reads/sec	MB of read per second
MB Writes	Total MB of write
MB Writes/sec	MB of write per second

Table 6-2 Intel® CAS – Extended Statistics

Average of Page Sizes Read	Average number of 4k-page due to read
Average of Page Sizes Written	Average number of 4k-page due to write
Blocked Requests	Blocked request due to cache contention
Blocks Compulsory Misses	Number of misses in blocks due to the cache being empty
Blocks Conflicts Misses	Number of capacity misses in blocks
Blocks Invalid Misses	Number of misses in blocks because the block is being updated
Blocks Non-sequential Hits	Number of random hits in blocks
Blocks Reads	Number of actual blocks read in blocks
Blocks Sequential Hits	Number of sequential hits in blocks
Blocks Writes	Number of actual write in blocks
Bypassed Read Requests	Number of read request sent to primary storage directly even it might be in include/pin list (ex: error handling)
Bypassed Write Requests	Number of write request sent to primary storage directly even it might be in include/pin list (ex: error handling)
Cache Full Misses	Number of full cache misses
Cache Hits	Number of full cache hits
Cache Non-sequential Hits	Number of non-sequential cache hits
Cache Partial Misses	Number of partial cache misses
Cache Sequential Hits	Number of sequential cache hits
Maximum of Page Sizes Read	Maximum number of 4k-page due to read
Maximum of Page Sizes Written	Maximum number of 4k-page due to write
Minimum of Page Sizes Read	Minimum number of 4k-page due to read
Minimum of Page Sizes Written	Minimum number of 4k-page due to write
Random Requests (128p)	Number of random requests with more than 128-page seeks between the current and previous IO in the primary storage.
Random Requests (16p)	Number of random requests with more than 16-page seeks between the current and previous IO in the primary storage.
Random Requests (1p)	Number of random requests with more than 1-page seeks between the current and previous IO in the primary storage.
Random Requests (32p)	Number of random requests with more than 32-page seeks between the current and previous IO in the primary storage.
Random Requests (64p)	Number of random requests with more than 64-page seeks between the current and previous IO in the primary storage.

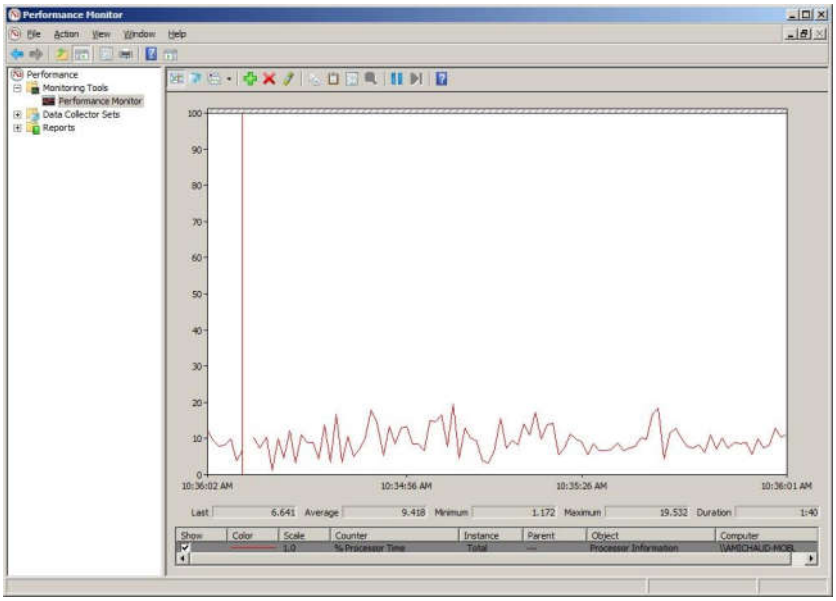
Read Requests	Number of read IO
Sequential Requests (128p)	Number of sequential requests with less than 128-page seeks between the current and previous IO in the primary storage.
Sequential Requests (16p)	Number of sequential requests with less than 16-page seeks between the current and previous IO in the primary storage.
Sequential Requests (1p)	Number of sequential requests with less than 1-page seeks between the current and previous IO in the primary storage.
Sequential Requests (32p)	Number of sequential requests with less than 32-page seeks between the current and previous IO in the primary storage.
Sequential Requests (64p)	Number of sequential requests with less than 64-page seeks between the current and previous IO in the primary storage.
Serviced Requests	Total number of IO not by-passed
Total Requests	Total number of IO (serviced plus by-passed will be total)
Variance of Page Sizes Read	Variance of different page sizes due to read
Variance of Page Sizes Written	Variance of different page sizes due to write
Write Requests	Number of write IO

6.2 Viewing Cache Statistics in Perfmon

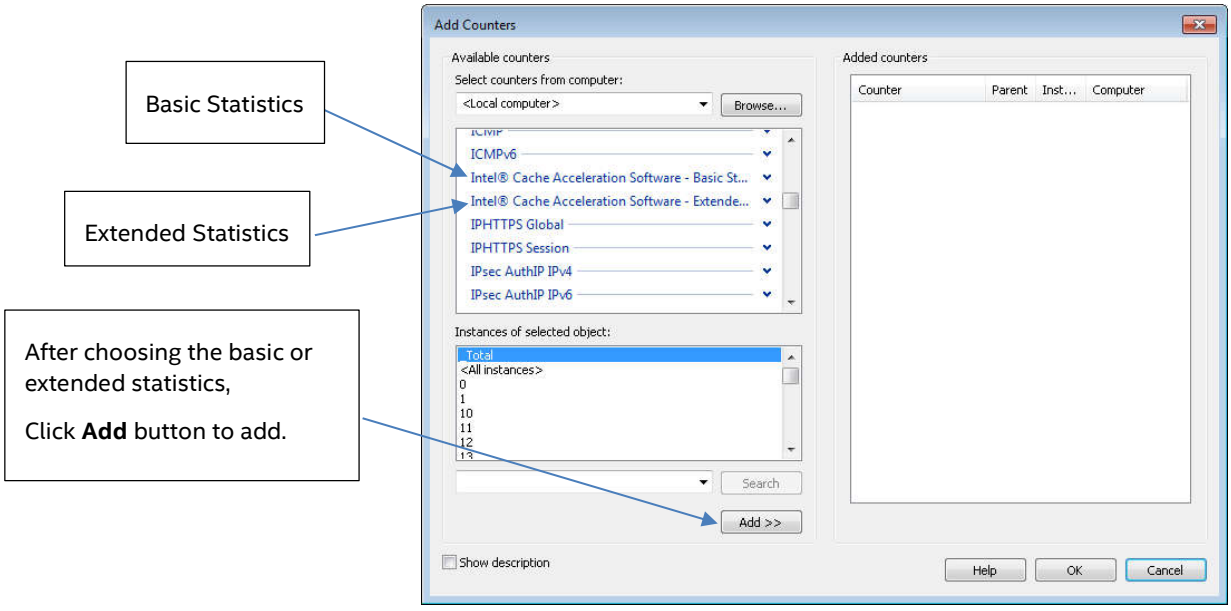
The performance and operation statistics of Intel® CAS are managed using Windows* Performance Monitor (`perfmon`), which is included by default with the supported Windows* operating systems.

To view cache statistics in Performance Monitor:

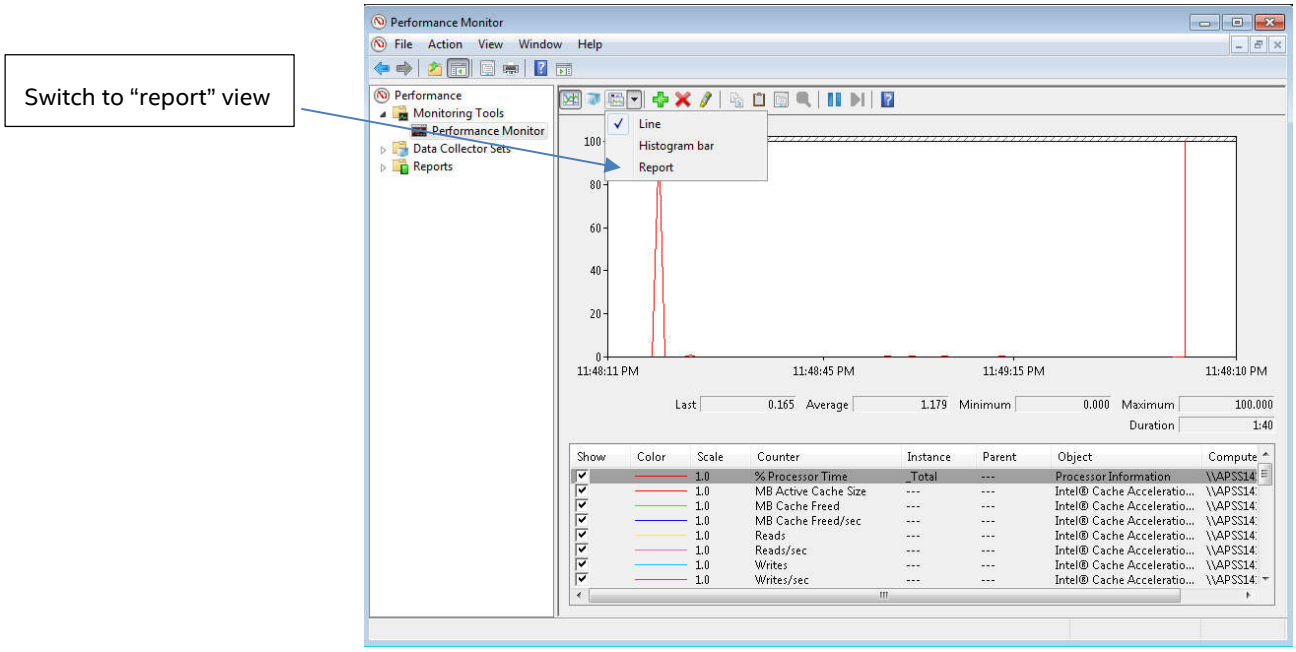
1. Type *perfmon* in the *Start Search* box, and press *Enter.*
2. Click *Performance Monitor on the left panel* to display Performance Monitor screen.



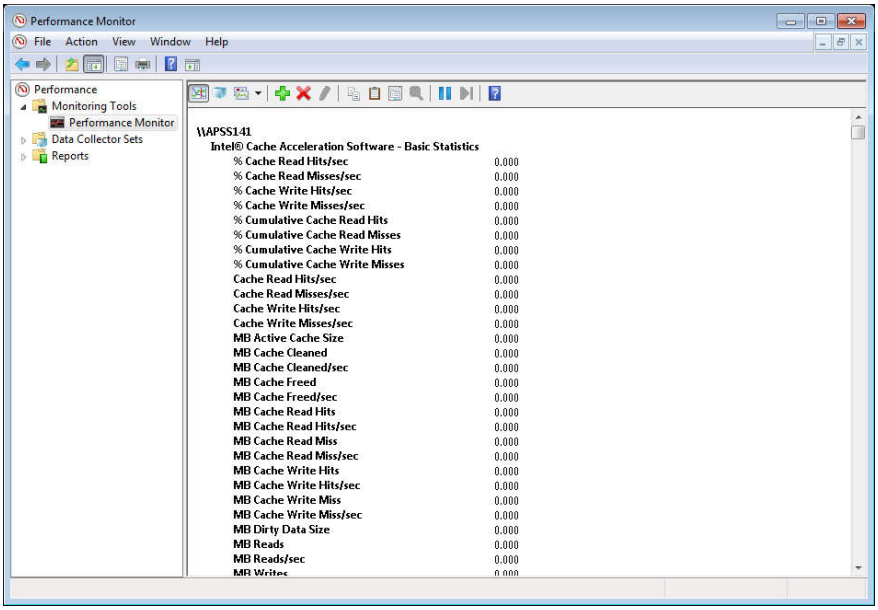
3. Click the green "+" icon on the toolbar to display the *Add Counters* screen.
   Scroll down to find *Intel Cache Acceleration Software – xxx Statistics*



4. Switch view mode to "report"



5. View cache statistics



7 Power State

7.1 Standby/Hibernation (S3/S4)

System with Intel® CAS being turned on will continue to be able to do S3/S4. Caching will be turned off before entering S3/S4 and will resume after exiting S3/S4.

7.2 Shutdown (S5)

Cache configuration and content will be kept over power cycle. On next system reboot, cache will restart as warm cache.

7.3 Unexpected Power Loss with Black Screen

After an unexpected power loss, the cache will start with the next reboot. Cache will be partially warm. In that case cache will be rebuilt only based on dirty data (data which were not synchronized between SSD and HDD in write back mode), so this works for write back mode only, or for a case when cache mode was switched from write back mode to another without flushing dirty data. All data which were marked as cleaned will not be in cache after such OS starts.

This allows the cache to start quickly, and OS boot time should take be similar as during typical boot procedure.

If using caching in write-through mode, there will be no extra risk of data loss due to caching in unexpected power loss. If using caching in write-back mode, it is possible the cache can be recovered successfully. But it is also possible cache cannot be recovered. So there is increased risk of data loss with unexpected power loss. Be cautious when using write-back mode.

To reduce the chance of data loss, consider disabling write back caching in HDDs and using the flush command often. To avoid the chance of data loss, consider using power backup.

8 Appendix

Frequently Asked Questions

A.1 "Functionality" Related

How do I delete all the cache content?

To delete all cache content, click the *Stop Cache* button in the Intel® CAS GUI.

Why can't I make any configuration changes?

You must log on as an administrator or a user with administrator privileges to make any configuration changes.

Why pinning doesn't work for me?

When the files you want to pin are used by other applications, Intel® CAS will not be able to pin them. For example, for files that are locked and in use (such as Microsoft SQL Server database files), we recommend stopping the application before adding those files to the cache.

Can I pin a file larger than cache? What happens when pinned file grows larger than cache?

No, you can't pin a file larger than cache size. Once it exceeds the cache size, cache maintenance will start clearing a portion of the file that is least likely to be used in order for the cache to continue to reflect the hottest data. If you restart the cache, it will then refuse to pin the file.

How to manually install the patch to enable SHA-2 Certificates support on OS Windows Server 2008 R2

- Instructions for manually installing KB3033929 patch from Microsoft:
    - From another computer with access to the following website, enter KB3033929 into the search box
        - *https://www.microsoft.com/en-us/download*
    - Navigate to the version of Windows you wish to update, and click the download button.
    - Click **Save** to copy the download to your computer for installation at a later time and save the downloaded zip file to your USB device
    - Copy the zip file to a temp file on the platform OS, right click on this downloaded KB3033929 zip file and choose to run as an administrator. This will extract the actual hotfix patch onto C:\.
    - Navigate to this .exe file and double click it.
    - This runs the patch update.
    - Once the KB patch is installed successfully, restart the system and install Intel® CAS Software.

My installation on Windows Server 2008 R2 is failing with the message "Your system does not contain up-to date list of trusted Root Certificates and installation cannot be continued…" What should I do?

If you see this message, it means that you do not have the up-to data list of Trusted Root Certificates on your OS. In order to update the list of Trusted Root Certificates you can:

- Connect your machine to internet. This will cause your system to update this list
- If you do not want to connect your machine to the internet you must manually download the missing certificate from the vendor site using other machines connected to network

    https://support.comodo.com/index.php?/Default/Knowledgebase/Article/View/917/91/

    Manually copy certificate file (addtrustexternalcaroot.crt) it into your machine with Intel® CAS

Install this certificate in following way:

- Click on start menu and type: “mmc”
- Click on “File” in the console root
- Choose “Add / Remove Snap-in” from the drop down menu
- Click on “Certificates” in the left menu items
- Click the “Add” button
- Select “Computer account” radio button
- Select “Next”
- “Select Computer” screen appears, select “Finish”
- On “Add or Remove Snap-ins” screen, select “OK”
- Click on "Certificates (Local Computer)” from “Console1- [Console Root]"
- Right click on "Trusted Root Certification Authorities (outline item)" in "Console1 - [Console Root]"
- Click on "Import... (menu item)"
- Click "Next" in "Certificate Import Wizard"
- Click "Browse... (push button)" in "Certificate Import Wizard"
- Navigate to where addtrustexternalcaroot.crt was copied to your machine
- Double click on addtrustexternalcaroot.crt
- Click “Next” in “Certificate Import Wizard”
- Click “Finish” then “OK”

A.2 “Performance” Related

How do I tell what applications need more I/O?

Disk usage statistics are recorded in Windows* Performance Monitor (`perfmon`), which is included by default with the supported Windows OSes*. Two counters that can be monitored to determine overall disk I/O activity are:

- PhysicalDisk: % Disk Time (percentage of time that the disk is busy with I/O)
- PhysicalDisk: Avg. Disk Queue Length (how many system requests are waiting for disk access)

Individual applications may have specific counters to determine the amount of I/O generated by the application. For example, in Microsoft* SQL Server:

- SQL Server:Buffer Manager:Page reads/sec
- SQL Server:Buffer Manager:Page writes/sec

Refer to “Chapter 6 Monitoring the Caching” for more information on monitoring Intel® CAS performance.

How do I test performance?

In addition to Windows* Performance Monitor, there are several third-party tools which can help you test I/O performance on your applications and system, including IOMeter* (*http://www.iometer.org/*) for overall I/O performance, and sysbench for SQL (*http://dev.mysql.com/downloads/benchmarks.html*)

Performance is slower than I expect. What can I do?

- Instead of using default caching everything policy, consider to use a customized cache policy by using include or pin.
- Make sure you have warmed up the cache before taking the performance benchmarking.
- Make sure your workload has “hot spot”, i.e. has data which is used more than once. If your workload has no “hot spot”, Intel® CAS will not be able to boost the performance, which is true for any caching solution.
- If you have pinned files, ensure that their combined size does not exceed the physical cache size since there may be performance penalty if that occurs. You may need to install a larger cache drive to avoid this performance issue.
- If you have pinned file, make sure all the pinned files cached into SSD before starting benchmarking.

My memory is running low after turning on Intel® CAS

Intel® CAS uses memory for metadata. The amount of memory we need is proportional to size of caching. This is true for any caching software solution. You could add more memory or shrink the size of the caching device used for cache.

Intel® CAS performance counters fail. What should I do?

If the exception *Setting up performance counters failed* displays, you must rebuild the configuration registry key by running `lodctr /R` from a Windows* command prompt. Information regarding Performance Monitor Counters is stored in the registry and this exception implies that the configuration registry key is invalid. This is a known issue with Windows* performance counters.

A.3 "Support" Related

How do I contact technical support?

Contact technical support by phone at 1-800-404-2284 or at the following URL:

http://www.intel.com/p/en_US/support/highlights/sftwr-prod/cas

Does Intel® CAS work with any SSD?

By theory, Intel® CAS should work with any SATA or NVMe* SSD. However, following are advantages to use Intel SSDs.

- Optimized performance for Intel SSDs
- Unique features for Intel SSDs (in roadmap already)
- We only validate with Intel SSDs
- Get favorable price with Intel SSD, and even better bundle price with Intel Data Center SSDs.
- The criteria to choose a caching SSD is higher than choosing a regular storage SSD. Caching SSD needs to have:
    - Premium performance
    - Premium endurance
    - Advanced features like power loss protection

What happens when my trial expires?

Intel® CAS will still be running, but only stop cache will be available. All other options will be blocked. User will be able to read data from caching SSD, not be able to write any data to caching SSD. Also when stopping the cache (manually) after trial expires, it is not possible to start it again.

If you have not finished the evaluation, please contact us. We will be happy to extend your trial.