To: T10 Technical Committee
From: Mark Overby, NVIDIA Corporation (moverby@nvidia.com)
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Subject: T10/08-018r3 SAT-2: NV Cache Translation

Revision History
Revision 0 - Initial draft of document
Revision 1 - Revised proposal to use commands instead of doing through mode pages
Revision 2 - Beginning shift to command based mechanisms using MAINTANENCE IN (12)
Revision 3 - Added MAINTANENCE OUT (10) version as well as moved to MAINTANENCE IN (16)
Revised SPC-4 changes

Related Documents
SAT-2 (T10/1699-D) Revision 4
SPC-4 (T10/1731-D) Revision 14

1 Overview

This proposal creates a translation from the ATA non-volatile cache feature set into a combination of the SBC non-volatile cache and SAT-specific mode pages to control the behavior of the cache.

2 Document Changes

2.1 Changes to SPC-4 (r14)

Replace Table D.6 with the following:

Table D.6 — SERVICE ACTION IN (16) and SERVICE ACTION OUT (16) service actions

Service Action	Description
SERVICE ACTION IN (16) [Operation Code 9Eh]	
00h - 0Eh	Reserved
0Fh	Restricted (See SAT-2)
10h - 1Fh	Restricted
SERVICE ACTION OUT (16) [Operation Code 9Fh]	
00h - 0Fh	Reserved
10h - 1Fh	Restricted

Replaced MAINTENANCE OUT section of table D.4 as follows:

Table 1 —

Service Action	Description
MAINTENANCE (IN) [Operation Code A3h]	
...	
MAINTENANCE (OUT) [Operation Code A4h]	
00h - 05h	Restricted
06h	SET IDENTIFYING INFORMATION
07h - 09h	Restricted
0Ah	SET TARGET PORT GROUPS
0Bh	CHANGE ALIASES
0Ch - 0Dh	Reserved
0Eh	SET PRIORITY
0Fh	SET TIMESTAMP
10h	MANAGEMENT PROTOCOL OUT
11h	Restricted (See SAT-2)
12h - 1Eh	Reserved
1Fh	Vendor specific

2.2 Changes to SAT-2

2.2.1 Changes to parameters for SAT implementations

2.2.2 Non-Volatile Cache Log Page

The non-volatile cache log page reports that a non-volatile cache is present and for how long the data remains non-volatile. If the attached ATA device reports support for the non-volatile cache feature set (see [Extended Inquiry VPD Page Translation]), the SATL shall implement the translation for this log page. As ATA non-volatile caches are required to remain non-volatile under all circumstances, the SATL shall report that the caches are indefinitely non-volatile as described in the following translation.

Table 2 shows the translation of the fields for the returned parameter data. This translation shall be used for all defined non-volatile cache log parameters.

Table 2 — Non-volatile Cache Parameter Fields

Field	Changeable	Description or reference
PARAMETER LENGTH	n/a	Shall be set to 3h
REMAINING NON-VOLATILE TIME or MAXIMUM NON-VOLATILE TIME	n/a	Shall be set to FF_FFFFh

2.2.3 Changes to Vital product data parameters

2.2.4 Extended INQUIRY VPD Page

The SATL shall implement the Extended INQURY VPD Page (see table BB) if:

a) The NV_SUP bit is set to one; or
b) The PRIOR_SUP bit is set to one.

Table 3 — Extended INQUIRY VPD Page

Field	Description or Reference
PERIPHERAL QUALIFIER	Shall be set to 000b
PERIPHERAL DEVICE TYPE	Shall be set to 00h
PAGE CODE	Shall be set to 86h
PAGE LENGTH	Shall be set to 3Ch
SPT	Unspecified (see 3.4.2)
GRD_CHK	Unspecified (see 3.4.2)
APP_CHK	Unspecified (see 3.4.2)

Table 3 — Extended INQUIRY VPD Page

Field	Description or Reference
REF_CHK	Unspecified (see 3.4.2)
GROUP_SUP	Shall be set to zero
PRIOR_SUP	If the ATA device reports support for the NCQ priority feature (i.e., IDENTIFY DEVICE data word 76, bit 12 is set to one), then this field shall be set to one. Otherwise, this field shall be set to zero. See [NCQ Priority Translation].
HEADSUP	Unspecified (see 3.4.2)
ORDSUP	Unspecified (see 3.4.2)
SIMPSUP	Shall be set to one
COR_D_SUP	Shall be set to one if IDENTIFY DEVICE data word 119, bit 2 is set to one. Otherwise this field shall be set to zero.
NV_SUP	If the ATA device supports the non-volatile cache feature set (i.e. IDENTIFY DEVICE data word 214, bit 0 is set to one or IDENTIFY DEVICE data word 214, bit 4 is set to one), then this field shall be set to one. Otherwise, this field shall be set to zero.
V_SUP	If the ATA device write or read caches are enabled (i.e. IDENTIFY DATA word 85, bits 5 or 6 are set to one), this field shall be set to one. Otherwise, this field shall be set to zero.
LUICLR	Unspecified (see 3.4.2)

2.2.5 New SAT-specific SCSI extensions

2.2.6 SAT NON-VOLATILE CACHE CONTROL IN command

2.2.6.1 Overview

The SAT NON-VOLATILE CACHE CONTROL IN command (see Table ZZ) transfers data from the ATA device to the application client to obtain status or configuration information about the ATA non-volatile cache in the device.

Table 4 — SAT NON-VOLATILE CACHE CONTROL IN command

Byte / Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (9Eh)							
1	Reserved			SERVICE ACTION (0Fh)				
2	Reserved							
3								
4	(MSB)	STARTING LBA						
9								(LSB)
10	Reserved							
11								
12	(MSB)	RETURNED DATA LENGTH						
13								(LSB)
14	NON-VOLATILE CACHE SERVICE							
15	CONTROL							

The NON-VOLATILE CACHE SERVICE field (see table ZZ) specifies which non-volatile cache operation is being used.

Table 5 — NON-VOLATILE CACHE SERVICE **field**

Code	Description	Reference
01h	Query Non-Volatile Cache Misses	XX
02h	Query Non-Volatile Cache Pinned Set	YY
All other code values reserved		

The RETURNED DATA LENGTH field specifies the number of 512-byte data units (i.e., a value of one means 512 bytes, two means 1 024 bytes, etc.) that shall be transferred in the data-in buffer for the requested service action. A value of zero in this field indicates that 65 536 data units (i.e., 33 554 432 or 0200_0000h bytes) are requested for transfer.

The STARTING LBA field contents vary based on the NON-VOLATILE CACHE SERVICE field (see table ZZ).

2.2.6.2 Non-volatile cache in services

2.2.6.2.1 Query Non-Volatile Cache Misses

The query non-volatile cache miss service queries the non-volatile cache in the ATA drive for a list of the last 64 logical block addresses that were accessed and were not present in the non-volatile cache.

If the NON-VOLATILE CACHE SERVICE field is set to one, then the returned data length field shall be to set to one. If the RETURNED DATA LENGTH field is set to any other value, then the command shall be terminated with CHECK CONDITION status with a sense key of ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

The STARTING LBA field shall be ignored for this non-volatile cache service action and should be set to 0000h by the application client.

The SATL shall issue an ATA QUERY NV CACHE MISSES command to the ATA device for this service and place the data from the ATA device into the data-in buffer.

2.2.6.2.2 Query Non-Volatile Cache Pinned Set

This query non-volatile cache pinned set service queries the non-volatile cache in the ATA drive for a list of the current logical block addresses that are resident in the non-volatile cache.

The STARTING LBA field indicates the first LBA from which a scan for resident LBAs shall begin. The list of logical block addressed pinned in the non-volatile cache shall be returned in ascending order (see ATA8-ACS).

For this service, the SATL shall issue an ATA QUERY NV CACHE PINNED SET command to the ATA device with the ATA LBA field set to the value in the STARTING LBA field and with the ATA Count field set to the value in the RETURNED DATA LENGTH field.

The SATL shall place the returned data from the ATA device into the data-in buffer.

2.2.7 SAT NON-VOLATILE CACHE CONTROL OUT command

2.2.7.1 Overview

The SAT NON-VOLATILE CACHE CONTROL OUT command (see Table JJ) transfers data from the application client to the ATA device to control the ATA non-volatile cache.

Table 6 — SAT NON-VOLATILE CACHE CONTROL OUT command

Byte / Bit	7	6	5	4	3	2	1	0
0	OPERATION CODE (A4h)							
1	Reserved		NVC_IMM	SERVICE ACTION (11h)				
2	Reserved							
3								
4	(MSB) NVC SERVICE DATA							
5								(LSB)
6	NON-VOLATILE CACHE SERVICE							
7	(MSB) PARAMETER LIST LENGTH							
8								(LSB)
9	CONTROL							

The NON-VOLATILE CACHE SERVICE field (see table LL) specifies which non-volatile cache operation is being used.

Table 7 — NON-VOLATILE CACHE SERVICE **field**

Code	Description	Reference
01h	Enable non-volatile cache	2.2.7.2.1
02h	Disable non-volatile cache	2.2.7.2.2
03h	Enable non-volatile cache power mode	2.2.7.2.3
04h	Disable non-volatile cache power mode	2.2.7.2.4
05h	Add LBAs to non-volatile cache	2.2.7.2.5
06h	Remove LBAs from non-volatile cache	2.2.7.2.6
07h	Reserve non-volatile cache space	2.2.7.2.7
All other code values reserved		

The behavior of the NVC_IMM bit and NVC SERVICE DATA field depends on the service action (see table JJ).

The PARAMETER LIST LENGTH field specifies the number of 512-byte data units (i.e., a value of one means 512 bytes, two means 1 024 bytes, etc.) that shall be transferred from the data-out buffer for the requested service action. A value of zero in this field indicates that 65 536 data units (i.e., 33 554 432 or 0200_0000h bytes) are requested for transfer.

2.2.7.2 Non-volatile cache out services

2.2.7.2.1 Enable Non-Volatile Cache

This service requests that the SATL enable the non-volatile cache at an ATA device. No data is transferred from the data-out buffer for this command.

If the NON-VOLATILE CACHE SERVICE field is set to one, then the PARAMETER LIST LENGTH field shall be to set to zero. If the PARAMETER LIST LENGTH field is set to any other value, then the command shall be terminated with CHECK CONDITION status with a sense key of ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

The NVC_IMM bit and NVC SERVICE DATA field are ignored for this service.

For this service, the SATL shall issue an ATA NV CACHE ENABLE command to the ATA device.

2.2.7.2.2 Disable Non-Volatile Cache

This service requests that the SATL disable the non-volatile cache at an ATA device. No data is transferred from the data-out buffer for this command.

If the NON-VOLATILE CACHE SERVICE field is set to two, then the PARAMETER LIST LENGTH field shall be to set to zero. If the PARAMETER LIST LENGTH field is set to any other value, then the command shall be terminated with CHECK CONDITION status with a sense key of ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

The NVC_IMM bit and NVC SERVICE DATA field are ignored for this service.

For this service, the SATL shall issue an ATA NV CACHE DISABLE command to the ATA device.

2.2.7.2.3 Enable Non-Volatile Cache Power Mode

This service requests that the SATL enable the non-volatile cache power savings mode (see ATA8-ACS) at an ATA device. No data is transferred from the data-out buffer for this command.

If the NON-VOLATILE CACHE SERVICE field is set to three, then the PARAMETER LIST LENGTH field shall be to set to zero. If the PARAMETER LIST LENGTH field is set to any other value, then the command shall be terminated with CHECK CONDITION status with a sense key of ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

The NVC_IMM bit is ignored for this service.

The NVC SERVICE DATA field contains the minimum value, in seconds, that the device shall stay in the ATA active or idle power states after entering the active state to access its media when the non-volatile cache power savings mode is active.

For this service, the SATL shall issue an ATA SET NV CACHE POWER MODE command to the ATA device with the Count field set to the value in the NVC SERVICE DATA field.

2.2.7.2.4 Disable Non-Volatile Cache Power Mode

This service requests that the SATL disable the non-volatile cache power savings mode (see ATA8-ACS) at an ATA device. No data is transferred from the data-out buffer for this command.

If the NON-VOLATILE CACHE SERVICE field is set to four, then the PARAMETER LIST LENGTH field shall be to set to zero. If the PARAMETER LIST LENGTH field is set to any other value, then the command shall be terminated with CHECK CONDITION status with a sense key of ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

The NVC_IMM bit and NVC SERVICE DATA field are ignored for this service.

For this service, the SATL shall issue an ATA RETURN FROM NV CACHE POWER MODE command to the ATA device.

2.2.7.2.5 Add LBAs to Non-Volatile Cache

This service requests that the SATL add a list of logical block addresses and ranges, provided in the data-out buffer, to be permanently added to the non-volatile cache and that portion of the non-volatile cache be treated as media. This is referred to as the non-volatile cache pinned set (see ATA8-ACS). The format of the data in data-out buffer is described in ATA8-ACS.

The application client shall ensure that the data-out buffer is a multiple of 512-bytes and padded with zeros to achieve this alignment.

The NVC SERVICE DATA field is ignored for this service.

The NVC_IMM bit specifies, when set to one, that the ATA device not complete the ADD LBAS TO NV CACHE PINNED SET command until all requested LBAs have been made resident in the non-volatile cache.

For this service, the SATL shall issue an ATA ADD LBAS TO NV CACHE PINNED SET command to the ATA device with the ATA Count field set to the value in the PARAMETER LIST LENGTH field and bit zero of the ATA LBA field set to the value of the NVC_IMM bit.

2.2.7.2.6 Remove LBAs from Non-Volatile Cache

This service requests that the SATL remove a list of logical block addresses and ranges, provided in the data-out buffer, to be removed from the non-volatile cache and that portion of the non-volatile cache no longer be treated as media. The format of the data in data-out buffer is described in ATA8-ACS.

The application client shall ensure that the data-out buffer is a multiple of 512-bytes and padded with zeros to achieve this alignment.

The NVC SERVICE DATA field is ignored for this service.

The NVC_IMM bit specifies, when set to one, that the ATA device remove all logical block addresses from the non-volatile cache pinned set. When this bit is set, the parameter list length field is ignored and no data-out buffer is used.

For this service, the SATL shall issue an ATA ADD LBAS TO NV CACHE PINNED SET command to the ATA device with the ATA Count field set to the value in the PARAMETER LIST LENGTH field and bit zero of the ATA LBA field set to the value of the NVC_IMM bit.

2.2.7.2.7 Reserve Non-Volatile Cache Space

This service requests that the SATL reserve a multiple of the logical block-size region in the non-volatile cache to add logical block addresses to the pinned set (see ATA8-ACS). No data is transferred from the data-out buffer for this command.

If the NON-VOLATILE CACHE SERVICE field is set to seven, then the PARAMETER LIST LENGTH field shall be to set to zero. If the PARAMETER LIST LENGTH field is set to any other value, then the command shall be terminated with CHECK CONDITION status with a sense key of ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN CDB.

The NVC_IMM bit shall be ignored for this service.

The NVC SERVICE DATA field contains the number of logical blocks for which space is to be reserved in the non-volatile cache. The ATA device flushes logical blocks from its unpinned set, if necessary, in order to satisfy this request (see ATA8-ACS).

For this service, the SATL shall issue an ATA FLUSH NV CACHE command to the ATA device with the ATA LBA field set to the value in the NVC SERVICE DATA field.

2.2.8 Changes to SYNCHRONIZE CACHE (10) and SYNCHRONIZE CACHE (16)

Change Tables 43 and the field SYNC_NV as follows:

Table 8 — SYNCHRONIZE CACHE (10) CDB field translations

SYNC_NV	If the SYNC_NV bit is set to one, and the SATL has reported a non-volatile cache in the extended INQUIRY VPD page, then the SATL shall: 1) Issue a FLUSH NV CACHE command to the ATA device with the LBA field set to FFFF_FFFFh; 2) Issue a FLUSH NV CACHE command to the ATA device with the LBA field set to the value in the ATA LBA field returned from the previous FLUSH NV CACHE command; 3) Issue a FLUSH NV CACHE command to the ATA device with the LBA field set to zero; and 4) Continue further processing as required by the SYNCHRONIZE CACHE (10) translation.