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NVM Express® Technical Proposal for New Feature

Technical Proposal ID	**TP4141a Storage Tag Mask Enhancements**
Change Date	**2023-08-07**
Builds on Specification	**NVM Express NVM Command Set 1.0b**
References Specification	**TP4095a Namespace Capability Reporting**

Technical Proposal Author(s)

Name	Company
Judy Brock, Mike Allison, Bill Martin	Samsung
Walt Hubis	Micron

This proposal defines optional support for Storage Tag restrictions. In particular, it defines two levels of restricted support for Storage Tag Masking:

- Byte Granularity Masking
- Masking Not Supported

Revision History

Revision Date	Change Description
2022-02-04	Initial version
2022-02-11	Add text indicating error will be returned if LBSTM field bit masking restrictions are not met during namespace create operation.
2022-02-23	Incorporate Phase 2 feedback from WG walk-thru
2022-03-22	Phase 3 draft – add “Reported” column to Identify data structures. No further feedback received.
2022-04-04	Incorporate feedback from Dell EMC (David Black)
2022-04-05	Slight modification to QPIF field language
2022-04-07	Another modification to QPIF field language
2022-04-28	• In one case, 16BPISTM needs to be qualified by QTYPE • STMLA field needs to be further qualified by PIF=QTYPE • PIF=QTYPE value should only be allowed if Qualified Protection Information Format Support is enabled
2022-04-29	word-smithing from WG review of 04/28 changes
2022-07-29	Integrated
2022-08-15	Updated editorial comments per Mike Allison
2023-03-13	TP4141a: change QPIFS field bit assignment – was incorrectly assigned bit 2 in PIC field in ratified TP4141. In actuality, QPIFS field is assigned bit 3 in PIC field and STCRS (from TP4068c) is assigned bit 2. Bugzilla Bug 28.

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2023-03-29	Identifying this change is associated to Bug 28. Fixed the navigation pane. Updated dates for 2023.
2023-08-07	Integrated

Description for Changes Document for

NVM Express NVM Command Set Specification 1.0b

Feature Enhancement:

- Added the Qualified Protection Information Format Support (QPIFS) field to the NVM Command Set I/O Command Set specific Identify Namespace data structure (CNS 05h) (CSI 00h)
- Updated the 16BPISTS field to take the QPIFS field into account
- Added the Qualified Protection Information Format (QPIF) field to the Extended LBA Format Data Structure, NVM Command Set specific. This field indicates Protection Information Formats that are qualified by the Storage Tag Mask constraints.
- Defined a new coded value (QTYPE = 11b) to the PIF field which points to Protection Information Formats that are defined by the QPIF field
- Added the Storage Tag Masking Level (STML) field to the NVM Command Set I/O Command Set specific Identify Namespace data structure (CNS 05h) (CSI 00h)
- Updated the legal LBSTM field options to be qualified by the value in new Storage Tag Masking Level (STML) field.

New requirement / incompatible change:

  - TP4141a – QPIFS field bit assignment was changed from bit 2 to bit 3. In ratified TP4141, QPIFS field bit assignment is shown as bit 2 but in actuality, QPIFS field was ultimately assigned bit 3 in PIC field and STCRS (from TP4068c) is assigned bit 2.

- References:
  - TP4141a

Markup Conventions:

Black:	Unchanged (however, hot links are removed)
~~Red Strikethrough~~:	Deleted
Blue:	New
Blue Highlighted:	TBD values, anchors, and links to be inserted in new text.
<Green Bracketed>:	Notes to editor
Orange:	From TP4095a

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Modify portions of NVM Command Set Specification 1.0b as shown below:

Modify figure 100 in section 4.1.5.3 as shown below:

4.1.5.3 I/O Command Set Specific Identify Namespace Data Structure (CNS 05h)

Figure 100 defines the I/O Command Set specific Identify Namespace data structure for the NVM Command Set.

Figure 100: NVM Command Set I/O Command Set Specific Identify Namespace Data Structure (CSI 00h)

Bytes	O/M 1	Description	Reported[2]
7:0	O	**Logical Block Storage Tag Mask (LBSTM):** Identifies the mask for the Storage Tag field for the protection information (refer to section 5.1). The size of the mask contained in this field is defined by the STS field. If the size of the mask contained in this field is less than 64 bits, the mask is contained in the least-significant bits of this field. If end-to-end protection is not enabled in the namespace, then this field is ignored. If a) the Qualified Protection Information Format Support bit is set to '1'; and b) the Storage Tag Masking Level Attribute field is set to a value of 010b (i.e., Masking Not Supported); or a) end-to-end protection is enabled; b) 16b Guard Protection Information format is used; and c) the 16BPISTM bit is set to '1', then all bits in the mask shall be set to '1'. If the Qualified Protection Information Format Support bit is set to '1', then the Storage Tag Masking Level Attribute field imposes constraints on how the bits in the mask contained in this field are allowed to be configured.	No

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Figure 100: NVM Command Set I/O Command Set Specific Identify Namespace Data Structure (CSI 00h)

<table>
<tr><th>Bytes</th><th>O/M 1</th><th>Description</th><th>Reported[2]</th></tr>
<tr><td>8</td><td>O</td><td>Protection Information Capabilities (PIC): This field indicates the capabilities for the protection information formats.
<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:~~2~~4</td><td>Reserved</td></tr>
<tr><td>3</td><td>Qualified Protection Information Format Support (QPIFS): If set to ‘1’, then the namespace supports the Qualified Protection Information Format field (refer to Figure 101) and the Storage Tag Masking Level Attribute field. If cleared to ‘0’, then the namespace does not support the Qualified Protection Information Format field (refer to Figure 101) and does not support the Storage Tag Masking Level Attribute field.</td></tr>
<tr><td>2</td><td>Reserved <Editor: this bit was assigned to STCRS field in TP4068c></td></tr>
<tr><td>1</td><td>16b Guard Protection Information Storage Tag Mask (16BPISTM): If set to ‘1’, then the LBSTM field shall have all bits set to ‘1’ for the 16b Guard Protection Information. If cleared to ‘0’, then the Logical Block Storage Tag Mask field is allowed to have any bits set to ‘1’ for the 16b Guard Protection Information.

If the 16BPISTS bit is cleared to ‘0’, then the 16BPISTM bit should be ignored by the host.

If the Qualified Protection Information Format Support bit is set to ‘1’, the PIF field is set to 11b (i.e., Qualified Type), and the Storage Tag Masking Level Attribute is set to 010b (i.e., Masking Not Supported), then the 16BPISTM bit shall be set to ‘1’.</td></tr>
<tr><td>0</td><td>16b Guard Protection Information Storage Tag Support (16BPISTS): If set to ‘1’, then the end-to-end protection 16b Guard Protection Information format (refer to section 5.2.1.1) supports a non-zero value in the STS field. If cleared to ‘0’, then the end-to-end protection 16b Guard Protection Information format support requires that the STS field be cleared to 0h (i.e., the Storage Tag field is not supported).

If the 32b Guard Protection Information or 64b Guard Protection Information is supported in any LBA format (refer to Figure 97 and Figure 100), then this bit shall be set to ‘1’.</td></tr>
</table></td><td>Yes</td></tr>
</table>

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Figure 100: NVM Command Set I/O Command Set Specific Identify Namespace Data Structure (CSI 00h)

<table>
<tr><th>Bytes</th><th>O/M 1</th><th>Description</th><th>Reported[2]</th></tr>
<tr><td>9</td><td>O</td><td>Protection Information Format Attribute (PIFA): This field indicates attributes of the Protection Information Format supported by the namespace.

<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>7:3</td><td>Reserved</td></tr>
<tr><td>2:0</td><td>Storage Tag Masking Level Attribute (STMLA): This field indicates the type of storage tag masking the namespace supports:

<table>
<tr><th>Value</th><th>Definition</th></tr>
<tr><td>000b</td><td>Bit Granularity Masking: Unless otherwise specified, the bits in the Logical Block Storage Tag Mask fields (refer to Figure 100 and Figure 105) may be any combination of ‘1’s and ‘0’s.</td></tr>
<tr><td>001b</td><td>Byte Granularity Masking: The value of all bits within any individual byte in the Logical Block Storage Tag Mask fields (refer to Figure 100 and Figure 105) shall be the same, but that value may differ from one byte to another, and the value of all bits within any partial high-order byte that may exist in the Logical Block Storage Tag Mask fields shall be the same.</td></tr>
<tr><td>010b</td><td>Masking Not Supported: Each bit in the Logical Block Storage Tag Mask field (refer to Figure 105) is required to be set to ‘1’ when creating a namespace using the Namespace Management command (refer to section 4.1.6).</td></tr>
<tr><td>011b to 111b</td><td>Reserved</td></tr>
</table>
If the Qualified Protection Information Format Support bit (refer to Figure 100) is cleared to ‘0’ or the PIF field is set to a value other than 11b (i.e., other than Qualified Type), then this field shall be cleared to 000b.</td></tr>
</table>
.</td><td>Yes</td></tr>
<tr><td>11:~~9~~10</td><td></td><td>Reserved</td><td></td></tr>
<tr><td colspan="3">Extended LBA Format</td><td></td></tr>
<tr><td>15:12</td><td>O</td><td>Extended LBA Format 0 Support (ELBAF0): This field indicates additional LBA Format 0 information related to the LBA Format 0 Support (LBAF0) field in the Identify Namespace data structure. The Extended LBA format field is defined in Figure 101.</td><td>Yes</td></tr>
<tr><td>19:16</td><td>O</td><td>Extended LBA Format 1 Support (ELBAF1): This field indicates additional LBA Format 1 information related to the LBA Format 1 Support (LBAF1) field in the Identify Namespace data structure. The Extended LBA format field is defined in Figure 101.</td><td>Yes</td></tr>
<tr><td>…</td><td>…</td><td>…</td><td></td></tr>
<tr><td>267:264</td><td>O</td><td>Extended LBA Format 63 Support (ELBAF63): This field indicates additional LBA Format 63 information related to the LBA Format 63 Support (LBAF63) field in the Identify Namespace data structure. The Extended LBA format field is defined in Figure 101.</td><td>Yes</td></tr>
<tr><td>4095:268</td><td>O</td><td>Reserved</td><td></td></tr>
<tr><td colspan="3">NOTES:
1. O/M definition: O = Optional, M = Mandatory
2. Identifies fields that report information for the Identify command when querying the capabilities of LBA formats</td><td></td></tr>
</table>

Modify figure 101 in section 4.1.5.3 as shown below:

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Figure 101: Extended LBA Format Data Structure, NVM Command Set Specific

<table>
<tr><th>Bits</th><th>Description</th></tr>
<tr><td>31:~~9~~13</td><td>Reserved</td></tr>
<tr><td>12:9</td><td>Qualified Protection Information Format (QPIF):
If:
a) the Protection Information Format (PIF) field is set to a value of 11b (i.e., Qualified Type); and
b) end-to-end protection information is enabled on a namespace formatted with this LBA format,
then
a) this field indicates the protection information format (refer to section 5.2.1); and
b) that protection information format is qualified by the Storage Tag Mask constraints, if any, indicated by the Storage Tag Masking Level Attribute field (refer to Figure 100).

If the PIF field is set to a value other than 11b (i.e., Qualified Type) then this field is ignored.
<table><tr><th>Value</th><th>Definition</th></tr><tr><td>0h</td><td>16b Guard Protection Information</td></tr><tr><td>1h</td><td>32b Guard Protection Information</td></tr><tr><td>2h</td><td>64b Guard Protection Information</td></tr><tr><td>3h to Fh</td><td>Reserved</td></tr></table></td></tr>
<tr><td>8:7</td><td>Protection Information Format (PIF): This field indicates the protection information format (refer to section 5.2.1) when end-to-end protection information is enabled on a namespace formatted with this LBA format.
<table><tr><th>Value</th><th>Definition</th></tr><tr><td>00b</td><td>16b Guard Protection Information</td></tr><tr><td>01b</td><td>32b Guard Protection Information</td></tr><tr><td>10b</td><td>64b Guard Protection Information</td></tr><tr><td>11b</td><td>~~Reserved~~ Qualified Type (QTYPE): If the Qualified Protection Information Format Support bit is set to ‘1’, then the protection information format is as defined in the Qualified Protection Information Format (QPIF) field. If the Qualified Protection Information Format Support bit is cleared to ‘0’, then this value shall not be used.</td></tr></table></td></tr>
<tr><td>6:0</td><td>Storage Tag Size (STS): Identifies the number of most significant bits of the protection information Storage and Reference Space field that define the Storage Tag field (refer to section 5.2.1.4).

This field does limit the minimum and maximum values allowed per protection information formats (refer to section 5.2.1):
<table><tr><th>Protection Information Format</th><th>Minimum Value</th><th>Maximum Value</th></tr><tr><td>16b Guard Protection Information</td><td>0</td><td>32</td></tr><tr><td>32b Guard Protection Information</td><td>16</td><td>64</td></tr><tr><td>64b Guard Protection Information</td><td>0</td><td>48</td></tr></table>If this field is cleared to 0h, then no bits of the Storage and Reference Space field are applied to the Storage Tag field and therefore the Storage Tag field is not defined.

For the 16b Guard Protection, if this field is set to 32, then no bits of the Storage and Reference Space field are applied to the Reference Tag field and therefore the Reference Tag field is not defined.

For the 64b Guard Protection, if this field is set to 48, then no bits of the Storage and Reference Space field are applied to the Reference Tag field and therefore the Reference Tag field is not defined.</td></tr>
</table>

Modify Section 4.1.6 as shown below:

4.1.6 Namespace Management command

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The Namespace Management command operates as defined in the NVMe Base Specification.

The host specified namespace management fields are specific to the I/O Command Set. The data structure passed to the create operation for the NVM Command Set (CSI 00h) is defined in Figure 105. Fields that are reserved should be cleared to 0h by host software. After successful completion of a Namespace Management command with the create operation, the namespace is formatted with the specified attributes.

If the LBA Format Extension Enable (LBAFEE) field is not set to 1h in the Host Behavior Support feature (refer to the Host Behavior Support section in the NVMe Base Specification), then a controller aborts a Namespace Management command with a status code of Invalid Namespace or Format that specifies to create a namespace that is formatted with (refer to section 5.2.1):

a) 16b Guard Protection Information with the STS field set to a non-zero value;
b) 32b Guard Protection Information; or
c) 64b Guard Protection Information.

Implementations may impose requirements on which bits are allowed to be masked in the Logical Block Storage Tag Mask field (refer to Figure 105). Those requirements are defined in the LBSTM field in Figure 100 and the Storage Tag Masking Level Attribute field in Figure 100. If any of the requirements specified in those two fields are not met, then the controller shall abort the command with a status code of Invalid Field in Command.

Figure 105: Namespace Management – Host Software Specified Fields

Bytes	Description	Host Specified
Fields that are a subset of the Identify Namespace data structure (refer to Figure 97)		
07:00	Namespace Size (NSZE)	Yes
15:08	Namespace Capacity (NCAP)	Yes
25:16	Reserved	
26	Formatted LBA Size (FLBAS)	Yes
28:27	Reserved	
29	End-to-end Data Protection Type Settings (DPS)	Yes
30	Namespace Multi-path I/O and Namespace Sharing Capabilities (NMIC)	Yes
91:31	Reserved	
95:92	ANA Group Identifier (ANAGRPID) [1]	Yes
99:96	Reserved	
101:100	NVM Set Identifier (NVMSETID) [1]	Yes
103:102	Endurance Group Identifier (ENDGID)	Yes
383:104	Reserved	
Fields that are not a subset of the Identify Namespace data structure.		
391:384	Logical Block Storage Tag Mask (LBSTM)	Yes
511:392	Reserved	

Notes:
1. A value of 0h specifies that the controller determines the value to use (refer to the Namespace Management section of the NVMe Base Specification). If the associated feature is not supported, then this field is ignored by the controller.

Modify Section 5.2.3 as shown below:

5.2.3 Control of Protection Information Checking - PRCHK

Checking of protection information consists of the following operations performed by the controller.

- …

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- … If a Storage Tag field is defined in the protection information (refer to section 5.2.1.4) and the Storage Tag Check bit in the command is set to ‘1’, then the controller compares unmasked bits in the Storage Tag field to the Logical Block Storage Tag (LBST) field of the command. A bit in the Storage Tag field is masked (i.e., not compared) if the corresponding bit is cleared to ‘0’ in the Logical Block Storage Tag Mask (LBSTM) field in the NVM Command Set Identify Namespace data structure (refer to Figure 100). Implementations may limit support for the bits that are allowed to be masked in the Logical Block Storage Tag Mask as described in the Storage Tag Masking Level Attribute field (refer to Figure 100).

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