To: INCITS Technical Committee T10
From: Fred Knight, NetApp
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Date: 16 November 2012
Subject: SBC-3 - LBP Threshold example Annex

1) *Revision history*

Revision 0 (Dec 22, 2010)
Revision 1 (Jan 4, 2011) Add third example with mixed types of reporting.
Revision 2 (Nov 1, 2012) Update based on CAP and other feedback.
Revision 3 (Nov 5, 2012) Update based on CAP feedback (pdf comments).
Revision 4 (Nov 16, 2012) Incorporate comments from r3 (now renumbered 13-001r0).

2) *Related documents*

sbc3r25 – SCSI Block Commands – 3

3) *Overview*

While working with various host vendors, the complexity of thresholds was very apparent. It became clear that a few examples could work wonders in improving understanding of how thresholds operate. This proposal adds an Informative annex with some threshold examples.

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Proposal:

Annex F
(informative)

Logical block provisioning reporting examples

F.1 Logical block provisioning reporting examples overview

Logical block provisioning reporting may be implemented using different methods. Implementations may include one or more of the following:

a) use of dedicated LBA mapping resources (e.g., resources are associated with a specific logical unit);
b) use of shared LBA mapping resources (e.g., resources are shared by multiple logical units);
c) reporting based on dedicated LBA mapping resources (e.g., resources are reported specific to the logical unit);
d) reporting based on shared LBA mapping resources (e.g., resources are reported for the resource pool as a whole);
e) LBA mapping resource tracking based on logical blocks; and
f) LBA mapping resource tracking based on threshold sets.

This annex describes examples of logical block provisioning reporting. Each example follows logical block provisioning resource usage and reporting over time as a specified set of operations occur.

F.2 Interpreting log parameter counts

Due to the variation of the threshold set size implementations, logical block usage and resource reporting may not have a direct relationship. The second example (see clause F.4) demonstrates an implementation where logical blocks are allocated on an individual basis, and reported using a larger threshold set basis. The reporting is a direct calculation from a logical block based count to a threshold set based count.

In implementations where a threshold set contains a set of contiguous logical blocks, the reporting may be substantially different. LUN 1 in the first example (see clause F.3) demonstrates such an implementation. At the initial conditions, two threshold sets are reported as being used. With a threshold set size of 1 024 blocks, these two threshold sets may contain as little as one logical block of application client data in each threshold set, or as many as 1 024 contiguous logical blocks in each threshold set. Which LBAs have been written by the application client will have a substantial impact on how the usage of those resources is reported.

The relationship of the physical blocks to the logical blocks (see Figure 4 and Figure 5) may have an impact on the logical block provisioning log parameters. Which LBAs are written by the application may impact the number of physical blocks required to be allocated and therefore impact the reporting of the LBA mapping resource parameters.

The device server may not prioritize the maintenance of the values in this log page above the completion of other operations (e.g., read operations or write operations). This may result in delays in updates to these values (e.g., after a request to unmap a large number of logical blocks). The logical block provisioning log parameters may also appear inaccurate for devices that perform unmap operations using a periodic background function.

As a result, application clients using logical block provisioning thresholds and examining logical block provisioning log parameters should not expect application client determined usage values or application client determined available space values to match log parameters or threshold events as reported by the logical unit.

F.3 Dedicated resource, threshold set tracked example

F.3.1 Dedicated resource, threshold set tracked example overview

This example describes a method that reports dedicated logical block provisioning resources based on threshold sets. In this example, the values reported by the logical unit in the Logical Block Provisioning log page (see 6.3.4) reflect the usage for each logical unit, and the available resources dedicated to each logical unit. Each threshold set is allocated to contain a set of contiguous logical blocks (e.g., LBAs 1024 to 2047 are contained in the same threshold set).

F.3.2 Dedicated resource, threshold set tracked example configuration

The configuration used for this example consists of two logical units, each with dedicated logical block provisioning resources. Table F.1 shows logical block provisioning related capacity values used in this example.

Table F.1 — Dedicated resource threshold set tracked example capacity information

LUN	Capacity [a]	THRESHOLD EXPONENT field [b]	Number of threshold sets [c]
1	4000_0000h (i.e., 1 GiB)	0Ah (i.e., 512 KiB, 1 024 logical blocks)	0010_0000h (i.e., 2 Mi)
2	C000_0000h (i.e., 3 GiB)	0Ch (i.e., 2 MiB, 4 096 logical blocks)	000C_0000h (i.e., 768 Ki)

[a]   RETURNED LOGICAL BLOCK ADDRESS field in READ CAPACITY parameter data (see 5.15.2 and 5.16.2).
[b]   In the Logical Block Provisioning VPD page (see 6.5.4).
[c]   Number of threshold sets = Capacity ÷ $2^{(threshold\ exponent)}$

Table F.2 shows LUN 1 with four enabled threshold descriptors and LUN 2 with two enabled threshold descriptors. The threshold descriptors in the Logical Block Provisioning mode page for LUN 1 are configured to report a logical block provisioning threshold crossing (see 4.7.3.8) when:

a) available LBA mapping resources reaches 30 % of reported capacity;
b) available LBA mapping resources reaches 20 % of reported capacity;
c) available LBA mapping resources reaches 10 % of reported capacity; or
d) used LBA mapping resources reaches 75 % of reported capacity.

The threshold descriptors in the Logical Block Provisioning mode page for LUN 2 are configured to report a logical block provisioning threshold crossing when:

a) available LBA mapping resources reaches 50 % of reported capacity; or
b) available LBA mapping resources reaches 10 % of reported capacity.

Table F.2 — Dedicated resource threshold set tracked example threshold descriptors

LUN	Threshold resource [a]	Threshold count [b]	Description
1	0001h	0004_CCCCh	An available LBA mapping resource threshold set to 30 % of the reported capacity (i.e., number of threshold sets from table F.1 × 0.30 = 0004_CCCCh threshold sets).
	0001h	0003_3333h	An available LBA mapping resource threshold set to 20 % of the reported capacity.
	0001h	0001_9999h	An available LBA mapping resource threshold set to 10 % of the reported capacity.
	0002h	000C_0000h	A used LBA mapping resource threshold set to 75 % of the reported capacity (i.e., number of threshold sets from table F.1 × 0.75 = 0007_5000h threshold sets).
2	0001h	0006_0000h	An available LBA mapping resource threshold set to 50 % of the reported capacity (i.e., number of threshold sets from table F.1 × 0.50 = 0006_0000h threshold sets).
	0001h	0001_3333h	An available LBA mapping resource threshold set to 10 % of the reported capacity.

[a]   THRESHOLD RESOURCE field in the Logical Block Provisioning mode page (see 6.4.6.2) and the PARAMETER CODE field in Logical Block Provisioning log page (see 6.3.4.2).
[b]   THRESHOLD COUNT field in the Logical Block Provisioning mode page.

F.3.3 Dedicated resource, threshold set tracked example sequence

The sequence of events for this example are:

1) Initial conditions (see F.3.4);
2) Operations that occur (see F.3.5); and
3) Final values in the logical block provisioning log page (see F.3.6).

F.3.4 Dedicated resource, threshold set tracked example initial conditions

Initially, LUN 1 has 2 threshold sets used, and has 69 108 736 logical blocks available (i.e. 0001_07A1h threshold sets). The application client has written at least one logical block into each logical block range that corresponds to a threshold set, therefore the application client may have written from 2 logical blocks to 2048 logical blocks. LUN 2 has 1 073 741 824 logical blocks available (i.e., 0004_0000h threshold sets). LUN 2 does not report a used LBA mapping resource parameter. Table F.3 shows the values in the Logical Block Provisioning log page for the initial conditions in this example.

Table F.3 — Dedicated resource threshold set tracked example initial conditions

LUN	Log page parameter [a]	Resource count [b]	Scope [c]	Description [d]
1	0001h	0001_07A1h	01b	The available LBA mapping resource parameter indicates that 69 108 736 logical blocks (i.e. 1_07A1h threshold sets × 1 024 logical blocks per threshold set) are available for LUN 1.
	0002h	0000_0002h	01b	The used LBA mapping resource parameter indicates that 2 048 logical blocks (i.e., 2h threshold sets × 1 024 logical blocks per threshold set) have been used (i.e., allocated) by LUN 1.
2	0001h	0004_0000h	01b	The available LBA mapping resource parameter indicates that 1 073 741 824 logical blocks (i.e., 4_0000h threshold sets × 4 096 logical blocks per threshold set) are available for LUN 2.

[a] THRESHOLD RESOURCE field in the Logical Block Provisioning mode page (see 6.4.6.2) and the PARAMETER CODE field in Logical Block Provisioning log page (see 6.3.4.2).
[b] RESOURCE COUNT field in the Logical Block Provisioning log page.
[c] SCOPE field in the Logical Block Provisioning log page
[d] LBA count = Resource Count × $2^{(\text{threshold exponent})}$

F.3.5 Operations that occur

Write operations occur to LUN 1 that require one additional threshold set to be allocated when the application client writes 50 additional contiguous logical blocks. Used LBA mapping resources on LUN 1 are now 3 072 logical blocks (i.e., three threshold sets), and available LBA mapping resources are 69 107 712 logical blocks. Write operations also occur to LUN 2 that require no additional threshold sets when the application client writes an additional 100 logical blocks into a threshold set that was already allocated.

F.3.6 Dedicated resource, threshold set tracked example final log page values

Table F.4 shows the values in the Logical Block Provisioning log page after the operations described in F.3.5 have occurred.

Table F.4 — Dedicated resource threshold set tracked example final log page values

LUN	Log page parameter [a]	Resource count [b]	Scope [c]	Description [d]
1	0001h	0001_07A0h	01b	The available LBA mapping resource parameter indicates that 69 107 712 logical blocks (i.e. 1_07A0h threshold sets × 1 024 logical blocks per threshold set) are available for LUN 1.
	0002h	0000_0003h	01b	The used LBA mapping resource parameter indicates that 3 072 logical blocks (i.e., 3h threshold sets × 1 024 logical blocks per threshold set) have been used (i.e., allocated) by LUN 1.
2	0001h	0004_0000h	01b	The available LBA mapping resource parameter indicates that 1 073 741 824 (i.e., 4_0000h threshold sets × 4 096 logical blocks per threshold set) are available for LUN 2.

[a]   THRESHOLD RESOURCE field in the Logical Block Provisioning mode page (see 6.4.6.2) and the PARAMETER CODE field in Logical Block Provisioning log page (see 6.3.4.2).
[b]   RESOURCE COUNT field in the Logical Block Provisioning log page.
[c]   SCOPE field in the Logical Block Provisioning log page.
[d]   LBA count = Resource Count × $2^{\text{(threshold exponent)}}$

F.4 Shared resource, logical block tracked example

F.4.1 Shared resource, logical block tracked example overview

This example describes a method that tracks shared logical block provisioning resources based on logical blocks. The logical block provisioning resources are shared by multiple logical units. In this example, the values reported by the logical unit in the Logical Block Provisioning log page (see 6.3.4) reflect the combined usage of the logical units that share the logical block provisioning resources, and the resources available for use by any of the logical units that share the logical block provisioning resources. Resources are allocated one logical block at a time but reported with a larger threshold set size.

F.4.2 Shared resource, logical block tracked example configuration

The configuration used for this example consists of two logical units, where the logical block provisioning resources are shared between both logical units. Table F.5 shows logical block provisioning related capacity values used in this example.

Table F.5 — Shared resource, logical block tracked example capacity information

LUN	Capacity [a]	THRESHOLD EXPONENT field [b]	Number of threshold sets [c]
1	4000_0000h (i.e., 1 GiB)	0Bh (i.e., 1 MiB, 2 048 logical blocks)	0008_0000h (i.e., 512 Ki)
2	C000_0000h (i.e., 3 GiB)	0Bh (i.e., 1 MiB, 2 048 logical blocks)	0018_0000h (i.e., 1 536 Ki)

[a]   RETURNED LOGICAL BLOCK ADDRESS field in READ CAPACITY parameter data (see 5.15.2 and 5.16.2).
[b]   In the Logical Block Provisioning VPD page (see 6.5.4).
[c]   Number of threshold sets = Capacity ÷ $2^{\text{(threshold exponent)}}$

F.4.3 Shared resource, logical block tracked example time line

The sequence of events for this example are:

1) Initial conditions (see F.4.4);
2) Operations that occur (see F.4.5); and
3) Final values in the logical block provisioning log page (see F.4.6).

F.4.4 Shared resource, logical block tracked example initial conditions

Initially, LUN 1 and LUN 2 have used a combined total of 57 000 logical blocks. LUN1 and LUN 2 have 1 073 741 900 logical blocks available for use by either LUN 1 or LUN 2. Table F.6 shows the values in the Logical Block Provisioning log page for the initial conditions.

Table F.6 — Shared resource, logical block tracked example initial conditions

LUN	Log page parameter[a]	Resource count[b]	Scope[c]	Description
1	0001h	0008_0000h	10b	The available LBA mapping resource parameter indicates that from 1 073 741 824 logical blocks (i.e. 8_0000h threshold sets × 2 048 logical block per threshold set) to 1 073 743 871 logical blocks are available for LUN 1 or LUN 2. [d]
	0002h	0000_001Ch	10b	The used LBA mapping resource parameter indicates that from 55 297 logical blocks to 57 344 logical blocks (i.e., 1Ch threshold sets × 2 048 logical blocks per threshold set) have been used (i.e., allocated) by LUN 1 and LUN 2. [e]
2	0001h	0008_0000h	10b	The available LBA mapping resource parameter indicates that from 1 073 741 824 logical blocks (i.e. 8_0000h threshold sets × 2 048 logical block per threshold set) to 1 073 743 871 logical blocks are available for LUN 1 or LUN 2. [d]

[a] THRESHOLD RESOURCE field in the Logical Block Provisioning mode page (see 6.4.6.2) and the PARAMETER CODE field in Logical Block Provisioning log page (see 6.3.4.2).
[b] RESOURCE COUNT field in the Logical Block Provisioning log page.
[c] SCOPE field in the Logical Block Provisioning log page
[d] Minimum available LBA count = Resource Count × $2^{(threshold\ exponent)}$
[e] Maximum used LBA count = Resource Count × $2^{(threshold\ exponent)}$

F.4.5 Operations that occur

Write operations occur to LUN 1 that require 2 000 additional logical blocks to be used and write operations occur to LUN 2 that require 3 000 additional logical blocks to be used. Used LBA mapping resources on LUN 1 and LUN 2 are now 62 000 logical blocks, and the combined LBA mapping resources available to both LUN 1 and LUN 2 are 1 073 736 900 logical blocks (i.e., 1 073 741 900 minus 5 000).

F.4.6 Shared resource, logical block tracked example final log page values

Table F.7 shows the values in the Logical Block Provisioning log page after the operations described in F.4.5 have occurred.

Table F.7 — Shared resource, logical block tracked example final log page values

LUN	Log page parameter[a]	Resource count [b]	Scope [c]	Description
1	0001h	0007_FFFDh	10b	The available LBA mapping resource parameter indicates that from 1 073 735 680 logical blocks (i.e. 7_FFFDh threshold sets × 2 048 logical blocks per threshold set) to 1 073 737 727 logical blocks are available for LUN 1 or LUN 2. [d]
	0002h	0000_001Fh	10b	The used LBA mapping resource parameter indicates that from 61 441 logical blocks to 63 488 logical blocks (i.e., 1Fh threshold sets × 2 048 logical blocks per threshold set) have been used (i.e., allocated) by LUN 1 and LUN 2. [e]
2	0001h	0007_FFFDh	10b	The available LBA mapping resource parameter indicates that from 1 073 735 680 logical blocks (i.e. 7_FFFDh threshold sets × 2 048 logical blocks per threshold set) to 1 073 737 727 logical blocks are available for LUN 1 or LUN 2. [d]

[a] THRESHOLD RESOURCE field in the Logical Block Provisioning mode page (see 6.4.6.2) and the PARAMETER CODE field in Logical Block Provisioning log page (see 6.3.4.2).
[b] RESOURCE COUNT field in the Logical Block Provisioning log page.
[c] SCOPE field in the Logical Block Provisioning log page
[d] Minimum available LBA count = Resource Count × $2^{(threshold\ exponent)}$
[e] Maximum used LBA count = Resource Count × $2^{(threshold\ exponent)}$

F.5 Shared available, dedicated used, logical block tracked example

F.5.1 Shared available, dedicated used, logical block tracked example overview

This example describes a method that tracks available shared logical block provisioning resources based on logical blocks and dedicated used logical block provisioning resources based on logical blocks. The available logical block provisioning resources are shared by multiple logical units. In this example, the values reported by the logical unit in the available LBA mapping resource parameter of the Logical Block Provisioning log page (see 6.3.4) reflect the resources available for use by any of the logical units that share the logical block provisioning resources. The values reported by the logical unit in the used LBA mapping resource parameter of the Logical Block Provisioning log page reflect the usage for the individual logical unit.

F.5.2 Shared available, dedicated used, logical block tracked example configuration

The configuration used for this example consists of two logical units, where the available logical block provisioning resources are shared between both logical units and used logical block provisioning resources are reported independently for each logical unit. Table F.8 shows logical block provisioning related capacity values used in this

example.

Table F.8 — Shared available, dedicated used example capacity information

LUN	Capacity [a]	THRESHOLD EXPONENT field [b]	Number of threshold sets [c]
1	4000_0000h (i.e., 1 GiB)	0Bh (i.e., 1MiB, 2 048 logical blocks)	0008_0000h (i.e., 512 Ki)
2	C000_0000h (i.e., 3 GiB)	0Bh (i.e., 1MiB, 2 048 logical blocks)	0018_0000h (i.e., 1 536 Ki)

[a] RETURNED LOGICAL BLOCK ADDRESS field in READ CAPACITY parameter data (see 5.15.2 and 5.16.2).
[b] In the Logical Block Provisioning VPD page (see 6.5.4).
[c] Number of threshold sets = Capacity $\div 2^{(\text{threshold exponent})}$

F.5.3 Shared available, dedicated used, logical block tracked example time line

The sequence of events for this example are:

1) Initial conditions (see F.5.4);
2) Operations that occur (see F.5.5); and
3) Final values in the logical block provisioning log page (see F.5.6).

F.5.4 Shared available, dedicated used, logical block tracked example initial conditions

Initially, LUN 1 has used 57 000 logical blocks and, LUN 2 has used 103 000 logical blocks. LUN 1 and LUN 2 have 1 073 741 900 logical blocks available for use by either LUN 1 or LUN 2. Table F.9 shows the values in the Logical Block Provisioning log page for the initial conditions.

Table F.9 — Shared available, dedicated used example initial conditions

LUN	Log page parameter[a]	Resource count [b]	Scope [c]	Description
1	0001h	0008_0000h	10b	The available LBA mapping resource parameter indicates that from 1 073 741 824 logical blocks (i.e. 8_0000h threshold sets × 2 048 logical blocks per threshold set) to 1 073 743 871 logical blocks are available for LUN 1 or LUN 2. [d]
	0002h	0000_001Ch	01b	The used LBA mapping resource parameter indicates that from 55 297 logical blocks to 57 344 logical blocks (i.e., 1Ch threshold sets × 2 048 logical blocks per threshold set) have been used (i.e., allocated) by LUN 1. [e]
2	0001h	0008_0000h	10b	The available LBA mapping resource parameter indicates that from 1 073 741 824 logical blocks (i.e., 8_0000h threshold sets × 2 048 logical blocks per threshold set) to 1 073 743 871 logical blocks are available for LUN 1 or LUN 2. [d]
	0002h	0000_0033h	01b	The used LBA mapping resource parameter indicates that from 102 401 logical blocks to 104 448 (i.e., 33h threshold sets × 2 048 logical blocks per threshold set) have been used (i.e., allocated) by LUN 2. [e]

[a] THRESHOLD RESOURCE field in the Logical Block Provisioning mode page (see 6.4.6.2) and the PARAMETER CODE field in Logical Block Provisioning log page (see 6.3.4.2).
[b] RESOURCE COUNT field in the Logical Block Provisioning log page.
[c] SCOPE field in the Logical Block Provisioning log page
[d] Minimum available LBA count = Resource Count × $2^{\text{(threshold exponent)}}$
[e] Maximum used LBA count = Resource Count × $2^{\text{(threshold exponent)}}$

F.5.5 Operations that occur

Write operations occur to LUN 1 that require 2 000 additional logical blocks to be used and write operations occur to LUN 2 that require 3 000 additional logical blocks to be used. Used LBA mapping resources on LUN 1 are now 59 000 logical blocks, used LBA mapping resources on LUN 2 are now 106 000 logical blocks, and the combined LBA mapping resources available to both LUN 1 and LUN 2 are 1 073 736 900 logical blocks.

F.5.6 Shared available, dedicated used example final log page values

Table F.10 shows the values in the Logical Block Provisioning log page after the operations described in F.5.5 have occurred.

Table F.10 — Shared available, dedicated used example final log page values

LUN	Log page parameter[a]	Resource count [b]	Scope [c]	Description
1	0001h	0007_FFFDh	10b	The available LBA mapping resource parameter indicates that from 1 073 735 680 logical blocks (i.e. 7_FFFDh threshold sets × 2 048 logical blocks per threshold set) to 1 073 737 727 logical blocks are available for LUN 1 or LUN 2. [d]
	0002h	0000_001Dh	01b	The used LBA mapping resource parameter indicates that from 57 345 logical blocks to 59 392 logical blocks (i.e., 1Dh threshold sets × 2 048 logical blocks per threshold set) have been used (i.e., allocated) by LUN 1. [e]
2	0001h	0007_FFFDh	10b	The available LBA mapping resource parameter indicates that from 1 073 735 680 logical blocks (i.e. 7_FFFDh threshold sets × 2 048 logical blocks per threshold set) to 1 073 737 727 logical blocks are available for LUN 1 or LUN 2. [d]
	0002h	0000_0034h	01b	The used LBA mapping resource parameter indicates that from 104 449 logical blocks to 106 496 logical blocks (i.e., 34h threshold sets × 2_048 logical blocks per threshold set) have been used (i.e., allocated) by LUN 2. [e]

[a] THRESHOLD RESOURCE field in the Logical Block Provisioning mode page (see 6.4.6.2) and the PARAMETER CODE field in Logical Block Provisioning log page (see 6.3.4.2).
[b] RESOURCE COUNT field in the Logical Block Provisioning log page.
[c] SCOPE field in the Logical Block Provisioning log page
[d] Minimum available LBA count = Resource Count × $2^{(threshold\ exponent)}$
[e] Maximum used LBA count = Resource Count × $2^{(threshold\ exponent)}$