SMART Attribute Annex

To: **T13 Technical Committee**
From: **Jim Hatfield**
Seagate Technology
389 Disc Drive
Longmont, CO 80503
Phone: 720-684-2120
Fax: 720-684-2722
Email: James.C.Hatfield@seagate.com
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Revision History:
0: Initial revision

1 Introduction

The purpose of this proposal is to add to ATA8-ACS as an informative Annex:

a) documentation for how to obtain SMART attributes from a device
b) an authoritative list of attribute numbers and names
c) specification of ranges for vendor-specific attributes
d) specification of ranges for reserved attribute numbers
e) an clear and unambiguous statement that the interpretation of attribute values and threshholds is strictly vendor-specific

In addition, this would enable T13 to be a central authority to which anyone could request the assignment of a new attribute id.

2 Background

The documentation of how to access SMART attributes was removed before the final draft of ATA/ATAPI-3. As I understand it, it was mainly a political issue. Drive vendors implemented attribute ‘X’ in different ways, with different measurement scales and units. Customers (not understanding that) were trying to compare vendor A with vendor B using the raw value of the attribute, and were making better/worse judgements that were completely baseless.

Since then, the industry has stabilized many of the attributes through common customer requirements being made of multiple drive vendors. Customers are more aware of the differences.\

Occasionally, there is a need for new attributes. Customers may dictate to drive vendors to implement attribute ‘X’, defined in such and such a way.

Sometimes, these attributes are intentionally kept undocumented to the public, in order to provide market differentiation between major OEMs.

There is another class of device users, however, in the open source community. These people still do not understand the differences, and they publish assertions and software claiming to tell you information that you ‘need to know’ about your ‘own property’ that ‘the others’ don’t want you to know. This proposal would at least make a clear statement about attributes (in the absence of any standard) about how to access and use the SMART attributes.

3 Proposal

I propose that the following text be incorporated into ATA8-ACS as an informative Annex.

3.1 SMART Attributes (Informative)

3.1.1 Overview

The information in this section was obsoleted in ATA/ATAPI-3. It is re-documented here for convenience, as it continues to be used by some devices. Clarification has been added, since the original text was too vague in places, and did not represent actual usage.

In late 1995, parts of SFF-8035i revision 2 (now obsolete) were merged with ATA/ATAPI-3.

Starting with ATA/ATAPI-4, there was no longer a requirement that a device maintain an attribute table. Devices from then on were only required to return (via SMART RETURN STATUS) an OK or NotOK to queries about their health. A 'NotOK' response indicates that the device considers itself 'likely to fail' (whatever that means). This left the interpretation of the values and threshholds completely up to the device itself, eliminating a major source of confusion for host software.

ATA/ATAPI-5 added SMART error logs and self-tests to enhance the ability of a drive to report on its health.

3.1.2 Attribute Values

An attribute is a one-byte value ranging from 1 to 253 (FDh). The initial default value is 100 (64h).

The value and the intertretation of the value are vendor-specific.

Attribute values are read-only to the host.

A device may report up to 30 attributes to the host.

Values of 00h, FEh and FFh are invalid.

When attribute values are updated by the device depends on the specific attribute. Some are updated as the disk operates, some are only updated during SMART self-tests, or at special events like power-on or unloading the heads of a disk drive, etc.

See section 3.1.6 for how a host may read the attribute values.

3.1.3 Attribute Threshholds

Each attribute may have an associated threshhold. When the value exceeds the threshhold, the attribute triggers a SMART 'threshhold exceeded' event. This event indicates that either the disk is expected to fail in less than 24 hours or it has exceeded its design or usage lifetime.

When an attribute value is greater than or equal to the threshhold, the threshhold is considered to be exceeded. A flag is set indicating that failure is likely.

There is no standard way for a host to read or change attribute threshholds from a device. There may be a vendor-specific mechanism.

See the SMART RETURN STATUS command for information about how a device reports that a threshhold has been exceeded.

3.1.4 Partial list of SMART Attributes Identifiers

This is a list of SMART attributes and names obtained from an opensource project.

[Note: This list was originally obtained from sourceforge.net, as compiled by Bruce Allen. I have edited some of the descriptions for grammar and spelling.]

This list is not intended to be comprehensive, complete or authoritative. Some of the IDs listed have other names and uses that are vendor-specific.

Some of these have been obsolete for a long time and are not supported.

The descriptions are vague and subject to multiple interpretations.

Consider everything in this list to be vendor-specific: scale, measurement units, threshholds, when they get cleared, minimum and maximum values.

Table 1 - Legacy Attribute IDs

Decimal	Hex	Name	Description
0	00h	Invalid	Invalid attribute identifier
1	01h	Raw read error rate	Frequency of errors while reading raw data from a disk
2	02h	Throughput performance	Average efficiency of a hard disk
3	03h	Spinup time	Time needed to spin up
4	04h	Start/Stop count	Number of spindle start/stop cycles
5	05h	Reallocated sector count	Quantity of remapped sectors
6	06h	Read channel margin	Reserve of channel while reading
7	07h	Seek error rate	Frequency of errors while positioning
8	08h	Seek timer performance	Average efficiency of operations while positioning
9	09h	Power-on hours count	Number of hours elapsed in the power-on state
10	0Ah	Spinup retry count	Number of retry attempts to spin up
11	0Bh	Calibration retry count	Number of attempts to calibrate the device
12	0Ch	Power cycle count	Number of power-on events
13	0Dh	Soft read error rate	Frequency of ‘program’ errors while reading from a disk
187	BBh	vendor-specific	vendor-specific
189	BDh	vendor-specific	vendor-specific
190	BEh	vendor-specific	vendor-specific
191	BFh	G-sense error rate	Fequency of mistakes as a result of impact loads
192	C0h	Power-off retract count	Number of power-off or emergency retract cycles
193	C1h	Load/Unload cycle count	Number of cycles into landing zone position
194	C2h	HDA temperature	Temperature of a hard disk assembly
195	C3h	Hardware ECC recovered	Number of ECC on-the-fly errors
196	C4h	Reallocation count	Number of remapping operations
197	C5h	Current pending sector count	Number of unstable sectors (waiting for remapping)
198	C6h	Offline scan uncorrectable count	Number of uncorrected errors
199	C7h	UDMA CRC error rate	Number of CRC errors during UDMA mode

Decimal	Hex	Name	Description
200	C8h	Write error rate	Number of errors while writing to disk (or) multi-zone error rate (or) flying height
201	C9h	Soft read error rate	Number of off-track errors
202	Cah	Data Address Mark errors	Number of Data Address Mark (DAM) errors (or) vendor-specific
203	CBh	Run out cancel	Number of ECC errors
204	CCh	Soft ECC correction	Number of errors corrected by software ECC
205	CDh	Thermal asperity rate (TAR)	Number of thermal asperity errors
206	CEh	Flying height	Height of heads above the disk surface
207	CFh	Spin high current	Amount of high current used to spin up the drive
208	D0h	Spin buzz	Number of buzz routines to spin up the drive
209	D1h	Offline seek performance	Drive's seek performance during offline operations
220	DCh	Disk shift	Shift of disk is possible as a result of strong shock loading in the store, as a result of falling (or) temperature
221	DDh	G-sense error rate	Number of errors as a result of impact loads as detected by a shock sensor
222	DEh	Loaded hours	Number of hours in general operational state
223	DFh	Load/unload retry count	Loading on drive caused by numerous recurrences of operations, like reading, recording, positioning of heads, etc.
224	E0h	Load friction	Load on drive caused by friction in mechanical parts of the store
225	E1h	Load/Unload cycle count	Total number of load cycles
226	E2h	Load-in time	General time for loading in a drive
227	E3h	Torque amplification count	Quantity efforts of the rotating moment of a drive
228	E4h	Power-off retract count	Number of power-off retract events.
230	E6h	GMR head amplitude	Amplitude of heads trembling (GMR-head) in running mode
231	E7h	Temperature	Temperature of a drive
240	F0h	Head flying hours	Time while head is positioning
250	FAh	Read error retry rate	Number of errors while reading from a disk

3.1.5 Attributes Identifiers defined by T13

These attribute identifiers are defined by T13. This is a comprehensive, complete and authoritative list.

Table 2 - Attributes defined by T13

Decimal	Hex	Name	Description
014 – 189	0Eh - BDh	Reserved	
210 – 219	D2h - DBh	Reserved	
229	E5h	Vendor-specific	
232 – 239	E8h - EFh	Vendor-specific	
241 – 249	F1h - F9h	Vendor-specific	
250 – 255	FBh - FFh	Vendor-specific	

3.1.6 How to Access SMART ATTRIBUTES

First, execute a SMART READ DATA command.

Bytes 0-361 (000h – 169h) of the data returned to the host are marked in Table 49 as 'Vendor specific'. Table 3 indicates how these bytes are mapped as the SMART Attribute Table.

Table 3 – SMART Attribute Table

Offset	Length (bytes)	Description
0	2	SMART structure version (this is vendor-specific)
2	12	Attribute entry 1
2+(12)	12	Attribute entry 2
		. . .
2+(12*29)	12	Attribute entry 30

Each valid entry in the attribute table is mapped as in Table 4. If any individual table entry is not valid, the attribute id for that entry shall be 00h. There is no requirement that attributes be in any particular order.

Table 4 - Entry in the Attribute Table

<table>
<tr><th>Length (bytes)</th><th>Description</th></tr>
<tr><td>1</td><td>Attribute ID
<table>
<tr><td>00h</td><td>This attribute table entry is invalid.</td></tr>
<tr><td>01h – FFh</td><td>This is a valid attribute table entry</td></tr>
</table></td></tr>
<tr><td>2</td><td>Flags
<table>
<tr><th>Bit</th><th>Description</th></tr>
<tr><td>0</td><td>Pre-fail/Advisory bit

This bit is applicable only when the value of this attribute is less than or equal to its threshhold.

0 : Advisory: The usage of age of the device has exceeded its intended design life period
1: Pre-failure notification:
Failure is predicted within 24 hours</td></tr>
<tr><td>1</td><td>Online data collection bit

0: This value of this attribute is only updated during offline activities
1: The value of this attribute is updated during both normal operation and offline activities</td></tr>
<tr><td>2 - 5</td><td>vendor-specific</td></tr>
<tr><td>6 - 15</td><td>reserved</td></tr>
</table></td></tr>
<tr><td>1</td><td>Value</td></tr>
<tr><td>8</td><td>Vendor-specific
This should not be compared with other devices or other vendors.</td></tr>
</table>