ecma INTERNATIONAL

Standard ECMA-405

1st Edition / December 2013

Data Interchange on Parallel Write/Read Disk Format for 5 Optical Disks

Standard

Rue du Rhône 114 CH-1204 Geneva T: +41 22 849 6000 F: +41 22 849 6001

is the registered trademark of Ecma International

COPYRIGHT PROTECTED DOCUMENT

Contents

Page

Introduction

Optical disks have been used widely. And the optical disks have advantage for long-term digital data preservation usage.

However, single-optical-disk based system has weaknesses for the data capacity and transfer rate compared to other devices. To meet the emerging demands for the long-term preservation of digital data, this proposal solves the issues by introducing multiple-disk based system. The system deals multiple disks as a set and writes/reads the set of disks in parallel.

Developing an industry standard is strongly needed for promoting the optical disk in the enterprise usage.

The new project for developing two standards, disk cassette & parallel write/read disk format for 5 disks, was proposed at the 95th meeting of TC31. These two draft standards were discussed at the 96th and 97th meetings of TC31. And then, TC31 agreed to bring these two draft standards to final draft standards.

This Ecma Standard has been adopted by the General Assembly of December 2013.

Data Interchange on Parallel Read/Write Disk Format for 5 Optical Disks

1 Scope

This Ecma Standard specifies optical disk formats that provide parallel read/write methods with written data divided among 5 disks.

This Ecma Standard specifies two types of optical disk formats:

- Non-parity disk type: This type allows for read/write operations on all user data divided among 5 disks.

- Parity disk type: This type allows for read/write operations on all user data divided among 4 disks and for read/write operations on parity data from/to 1 disk.

This Ecma Standard specifies the read/write area and the data structure.

2 Conformance

A claim of conformance with this Ecma Standard shall specify the type of optical disk format implemented. Recorded data that satisfy the mandatory requirements specified herein shall be in conformance with this Ecma Standard.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ECAM-94 *8-Bit Single Byte Coded Graphic Character Sets - Latin Alphabet No.1*, (ISO/IEC 8859-1, -2, -3 and -4), 2nd edition (June 1986)

ECMA-167 Volume and File Structure for Write-Once and Rewritable Media using Non-Sequential Recording for Information Interchange, 3rd edition (June 1997)

ECMA-XXX Cassette for 5 Optical Disks with 120 mm Diameter

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1
data
date sent from the file system

4.2
divided recording data
data divided into 64 kbytes blocks

4.3
formatting
operation that prepares the disk to record user data (through creation of a system management area and the UDF management area) as well as to record UDF 1.5 format data information

4.4
host
computer connected to the parallel read/write system

4.5
Info area
data area for Info data and temporal parity

4.6
info data
logical block address where VAT information and temporal parity information are written

4.7
last disk
disk that has the last divided recording data block includes the last logical block address data required by the file system

4.8
last logical block address
last logical block address required by the file system

4.9
last recorded disk
disk that has the last recorded logical cluster among 5 disks

4.10
last recorded logical cluster address
last logical cluster address at which data are recorded to media set

4.11
logical block
unit of allocation of a logical volume

NOTE The logical block size is 2 kbytes.

4.12
logical block address
address relative to the beginning of a partition

4.13
logical block address number
logical block address expressed in decimal

4.14
logical cluster
smallest unit to be recorded by division among multiple disks

NOTE The logical cluster size is 64 kbytes and consists of 32 logical blocks.

4.15
logical cluster set
set of identical logical cluster numbers among disks

4.16
logical cluster set number
logical cluster set expressed in decimal

4.17
media set
combination of 5 disks which are named Disk1, Disk2, Disk3, Disk4 and Disk5

4.18
packet
unit that can be recorded in one operation and that is an integer number of logical clusters

4.19
packet writing mode
recording technology that allows users to create, modify, and delete files and directories on demand without the need to write to a whole disk

4.20
parity disk
disk that records parity data

NOTE The parity disk shall be Disk 5.

4.21
start disk
disk that contains the first divided recorded data in a packet

NOTE The start disk includes the start logical block address data required by the file system.

4.22
start logical block address
first logical block address required by the file system

4.23
system management area
data area in which necessary information for the parallel write/read system is recorded

4.24
temporal parity
parity to be recorded to system management area if there is a disk to be unrecorded to the last logical cluster set in a packet

NOTE Temporal parity is used for parity disk types.

4.25
Universal Disk Format (UDF) management area
Data area in which user data sent from the file system are recorded

NOTE The file system can access this area.

4.26
user
person or other entity (e.g., an application) that causes the invocation of the services provided by an implementation

4.27
Virtual Allocation Table
VAT
provides a logical block address for each virtual address

NOTE The Virtual Allocation Table (VAT) is used on sequentially written media to give the appearance of randomly writable media to the system. The existence of this partition is identified in the partition maps. The VAT shall only be recorded on sequentially written media. The VAT is a map that translates Virtual Addresses to logical addresses. It shall be recorded as a file identified by a File Entry ICB (VAT ICB) that allows great flexibility in building the table. The VAT ICB is the last sector recorded in any transaction. The VAT itself may be recorded at any location.

5 Conventions and notations

Numbers in decimal notation are represented by the digits 0 to 9.

Numbers in hexadecimal notation are presented by the hexadecimal digits 0 to 9 and A to F in parentheses.

The setting of bits is denoted by ZERO and ONE.

6 Recording area for non-parity disk type

6.1 General

The recording area shall consist of system management area and UDF management area. The header, vendor-specific information, and parity information shall be recorded in the system management area in order to realize the parallel read/write method. Data sent from UDF file system shall be recorded in the UDF management area. The last logical block address of the UDF management area differs by the disk type used. The allocation of the recording area is specified in Figure 1.

<table>
<tr><td></td><td colspan="11">System management area</td><td colspan="3">UDF management area</td></tr>
<tr><td>Logical block address number</td><td>0</td><td>...</td><td>31</td><td>32</td><td>...</td><td>351</td><td>352</td><td>...</td><td>671</td><td>672</td><td>...</td><td>32x k+671</td><td>32x k+672</td><td>...</td><td>N</td></tr>
<tr><td>Disk1 to Disk5</td><td colspan="3">Header</td><td colspan="3">Reserved</td><td colspan="3">Vendor-specific information</td><td colspan="3">Info area</td><td colspan="3">Data</td></tr>
</table>

Here *k* is the logical cluster number of the Info area that the user selects, and N is the last logical block address. And *k* shall be more than or equal to 1.

Figure 1 — Recording area structure for non-parity disk type

6.2 System management area

6.2.1 General

The system management area is managed by the parallel read/write system. The system management area shall consist of a header, vendor-specific information, and the Info area. The size of the Info area is variable and selected by the user at formatting. The Info area size shall not be changed after formatting.

6.2.2 Header

The header shall consist of a parallel read/write identifier, parity disk applied identifier, logical cluster size, disk order number, cassette ID, media ID, vendor code, and vendor-specific information. The header format shall be as shown in Figure 2.

Relative byte position	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Remarks
0 to 15	(MSB) Parallel read/write identifier and revision number (LSB)								
16	Reserved							Parity	
17 to 19	Reserved								
20 to 23	(MSB) Logical cluster size (LSB)								
24 to 27	(MSB) Info area size (LSB)								
28	Disk order number								
29 to 31	Reserved								
32 to 43	(MSB) Cassette ID (LSB)								
44 to 47	Reserved								
48 to 63	Media ID								Media ID 1
64 to 79	Media ID								Media ID 2
80 to 95	Media ID								Media ID 3
96 to 111	Media ID								Media ID 4
112 to 127	Media ID								Media ID 5
128 to 2 047	Reserved								
2 048 to 4 097	Copy of Anchor volume descriptor pointer								
4 098 to 61 439	Reserved								
61 440 to 61 441	(MSB) Vendor code (LSB)								
61 442 to 65 535	Vendor-specific information 1								

Figure 2 — Header structure

Bytes 0 to 15: Parallel read/write identifier

These bytes shall specify the parallel read/write identifier and revision number and shall be filled with “R-format 1.0” in ASCII characters. Any other setting is prohibited in this Ecma Standard.

Byte 16: Parity disk applied identifier

This byte shall specify the identifier for whether the parity disk is applied. When the parity disk is applied, this byte shall be set to (01h). When parity disk is not applied, this byte shall be set to (00h).

Bytes 17 to 19

These bytes shall be reserved.

Bytes 20 to 23: Logical cluster size

These bytes shall specify the data size of the logical cluster and shall be set to (00 01 00 00h). Any other setting is prohibited in this Ecma Standard.

Bytes 24 to 27: Info area size

These bytes shall specify the info area size.

Byte 28: Disk order number

This byte shall specify the disk order number in the cassette expressed in hexadecimal.

Bytes 29 to 31

These bytes shall be reserved.

Bytes 32 to 43: Cassette ID

These bytes shall specify the cassette ID number.

Bytes 44 to 47

These bytes shall be reserved.

Bytes 48 to 63: Media ID for Disk1

These bytes shall specify the media ID for Disk1 as follows.

Bits 3 to 0 in byte 48 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 49 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 50 to 51 shall be reserved and set to (00h).

Bytes 52 to 63 shall be the disk serial number.

Bytes 64 to 79: Media ID for Disk2

These bytes shall specify the media ID for Disk2 as follows.

Bits 3 to 0 in byte 64 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 65 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 66 to 67 shall be reserved and set to (00h).

Bytes 68 to 79 shall be the disk serial number.

Bytes 80 to 95: Media ID for Disk3

These bytes shall specify the media ID for Disk3 as follows.

Bits 3 to 0 in byte 80 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 81 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 82 to 83 shall be reserved and set to (00h).

Bytes 84 to 95 shall be the disk serial number.

Bytes 96 to 111: Media ID for Disk4

These bytes shall specify the media ID for Disk4 as follows.

Bits 3 to 0 in byte 96 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 97 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 98 to 99 shall be reserved and set to (00h).

Bytes 100 to 111 shall be the disk serial number.

Bytes 112 to 127: Media ID for Disk5

These bytes shall specify the media ID for Disk5 as follows.

Bits 3 to 0 in byte 112 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 113 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 114 to 115 shall be reserved and set to (00h).

Bytes 116 to 127 shall be the disk serial number.

Bytes 128 to 2 047

These bytes shall be reserved and set to (00h).

Bytes 2 048 to 4 097: Copy of Anchor volume descriptor pointer

The Anchor Volume Descriptor Pointer contains three things of interest:

1. Static structures that may be used to identify and verify integrity of the disc.
2. Location of the Main Volume Descriptor Sequence
3. Length of the Main Volume Descriptor Sequence

Bytes 4 098 to 61 439

These bytes shall be reserved and set to (00h).

Bytes 61 440 to 61 441: Vendor code

These bytes shall specify the vendor code in ASCII characters, specified in ECMA-94.

Bytes 61 442 to 65 535: Vendor-specific information 1

These bytes are used for vendor-specific information.

The media ID structure shall be as shown in Figure 3.

Relative byte position	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Remarks
0	Reserved				(MSB)				
1	Manufacturer code (LSB)								
2 to 3	Reserved								
4 to 15	(MSB) Serial number (LSB)								

Figure 3 — Media ID structure

6.2.2.1 Info area

The Info area structure is different between the non-parity disk type and parity disk type.

The size of Info area can be selected by the user and shall not be changed after formatting, see Clause 6.1.

The Info area structure shall be as shown in Figure 4. The latest info data shall be recorded to Disk1 through Disk5 repeatedly. Info data shall consist of parallel read/write mode identifier, its revision number, and VAT logical block address.

	Info area			
Disk1	...	Info data at one before the latest	Latest Info data	Unrecorded
Disk2	...	Info data at one before the latest	Latest Info data	Unrecorded
Disk3	...	Info data at one before the latest	Latest Info data	Unrecorded
Disk4	...	Info data at one before the latest	Latest Info data	Unrecorded
Disk5	...	Info data at one before the latest	Latest Info data	Unrecorded

Figure 4 — Info area structure for non-parity disk type

The Info data structure for the non-parity disk type shall be as shown in Figure 5.

Info data shall be recorded in units of logical clusters to each disk of 5 disks in each packet.

The logical block address of VAT shall be recorded in order to reproduce the previously recorded data easily, even if the current data recording fails.

Relative byte position	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0 to 31	(MSB) Parallel read/write identifier and revision number (LSB)							
32 to 35	(MSB) VAT logical block address (LSB)							
36 to 32 767	Reserved							
32 768 to 65 535	Vendor-specific information 2							

Figure 5 — Info data structure for non-parity disk type

Bytes 0 to 31: Parallel read/write identifier and revision number

These bytes shall contain “R-Format-Information Rev1.0” in ASCII characters, specified in ECMA-94. Any other setting is prohibited in this Ecma Standard.

Bytes 32 to 35: VAT logical block address

These bytes shall contain the latest VAT logical block address in hexadecimal.

Bytes 36 to 32 767

These bytes shall be reserved and filled with (00h).

Bytes 32 768 to 65 535: Vendor-specific information 2

These bytes are used for vendor-specific information

6.3 UDF management area

The UDF management area shall be formatted for packet writing mode and shall be recorded so as to satisfy UDF 1.5. User data shall be recorded to each UDF management area on Disk1 through Disk5. The logical block address shall be from 32 x *k* + 672 to N.

The recording order of the divided recording data shall be as shown below and as shown in Figure 6.

1) Logical cluster 0 in the UDF management area on Disk1
2) Logical cluster 0 in the UDF management area on Disk2
3) Logical cluster 0 in the UDF management area on Disk3
4) Logical cluster 0 in the UDF management area on Disk4
5) Logical cluster 0 in the UDF management area on Disk5
6) Logical cluster 1 in the UDF management area on Disk1
7) Logical cluster 1 in the UDF management area on Disk2
8) Logical cluster 1 in the UDF management area on Disk3

9) Logical cluster 1 in the UDF management area on Disk4

10) Logical cluster 1 in the UDF management area on Disk5

11) …

In Figure 6, each column is a logical cluster set.

	Logical cluster								
	0	1	2	3	4	5		n-1	
Disk1	1	6	11	16	21	26		n x 5 +1	
Disk2	2	7	12	17	22	27		n x 5 +2	
Disk3	3	8	13	18	23	28		n x 5 +3	
Disk4	4	9	14	19	24	29		n x 5 +4	
Disk5	5	10	15	20	25	30		n x 5 +5	

Figure 6 — Recording order of divided recording data for non-parity disk type

7 Recording area for parity disk type

7.1 General

The recording area shall consist of the system management area and UDF management area. The header, vendor-specific information, and parity information shall be recorded in the system management area in order to realize the parallel read/write method. Data sent from the UDF file system shall be recorded in the UDF management area. The last logical block address of the UDF management area differs by disk type used. The allocation of recording area shall be as specified in Figure 7.

a) For Disk1 through Disk4

	System management area											UDF management area		
Logical block address number	0	...	31	32	...	351	352	...	671	672	...	32x *k*+671	32x *k*+672	...	N
Disk1 to Disk4	Header			Reserved			Vendor-specific information			Info area			Data		

b) For Disk5

	System management area													
Logical block address number	0	...	31	32	...	351	352	...	671	672	...	32x *k*+671	32x *k*+672	...	N
Disk5	Header			Reserved			Vendor-specific information			Info area			Parity		

Here *k* is the logical cluster number of Info area that user selects, and N is the last logical block address. And *k* shall be more than or equal to 1.

Figure 7 — Recording area for parity disk type

7.2 System management area

7.2.1 General

The system management area is managed by the parallel read/write system. The system management area shall consist of the header, vendor-specific information, info area, and parity data. The info area size is variable and selected by the user at formatting. The info area size shall not be changed after formatting.

7.2.2 Header

The parallel read/write identifier, parity disk applied identifier, logical cluster size, disk order number, cassette ID, media ID, vendor code and vendor-specific information 1 shall be recorded in the header. The header format shall be as shown in Figure 8.

Relative byte position	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Remarks
0 to 15	(MSB) Parallel read/write identifier and revision number (LSB)								
16	Reserved							Parity	
17 to 19	Reserved								
20 to 23	(MSB) Logical cluster size (LSB)								
24 to 27	(MSB) Info area size (LSB)								
28	Disk order number								
29 to 31	Reserved								
32 to 43	(MSB) Cassette ID (LSB)								
44 to 47	Reserved								
48 to 63	Media ID								Media ID 1
64 to 79	Media ID								Media ID 2
80 to 95	Media ID								Media ID 3
96 to 111	Media ID								Media ID 4
112 to 127	Media ID								Media ID 5
128 to 2 047	Reserved								
2 048 to 4 097	Copy of Anchor volume descriptor pointer								
4 098 to 61 439	Reserved								
61 440 to 61 441	(MSB) Vendor code (LSB)								
61 442 to 65 535	Vendor-specific information 1								

Figure 8 — Header structure

Bytes 0 to 15: Parallel read/write identifier

These bytes shall specify the parallel read/write identifier and revision number, and shall be filled with “R-format 1.0” in ASCII characters. Any other setting is prohibited in this Ecma Standard,

Byte 16: Parity disk applied identifier

This byte shall specify the identifier for whether the parity disk is applied. When the parity disk is applied, this byte shall be set to (01h). When the parity disk is not applied, this byte shall be set to (00h).

Bytes 17 to 19

These bytes shall be reserved.

Bytes 20 to 23: Logical cluster size

These bytes shall specify the data size of logical clusters and shall be set to (00 01 00 00h). Any other setting is prohibited in this Ecma Standard,

Bytes 24 to 27: Info area size

These bytes shall specify the info area size.

Byte 28: Disk order number

This byte shall specify the disk order number in the cassette expressed in hexadecimal.

Bytes 29 to 31

These bytes shall be reserved.

Bytes 32 to 43: Cassette ID

These bytes shall specify the cassette ID number.

Bytes 44 to 47

These bytes shall be reserved.

Bytes 48 to 63: Media ID for Disk1

These bytes shall specify the media ID for Disk1 as follows.

Bits 3 to 0 in byte 48 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 49 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 50 to 51 shall be reserved and set to (00h).

Bytes 52 to 63 shall be the disk serial number.

Bytes 64 to 79: Media ID for Disk2

These bytes shall specify the media ID for Disk2 as follows.

Bits 3 to 0 in byte 64 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 65 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 66 to 67 shall be reserved and set to (00h).

Bytes 68 to 79 shall be the disk serial number.

Bytes 80 to 95: Media ID for Disk3

These bytes shall specify the media ID for Disk3 as follows.

Bits 3 to 0 in byte 80 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 81 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 82 to 83 shall be reserved and set to (00h).

Bytes 84 to 95 shall be the disk serial number.

Bytes 96 to 111: Media ID for Disk4

These bytes shall specify the media ID for Disk4 as follows.

Bits 3 to 0 in byte 96 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 97 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 98 to 99 shall be reserved and set to (00h).

Bytes 100 to 111 shall be the disk serial number.

Bytes 112 to 127: Media ID for Disk5

These bytes shall specify the media ID for Disk5 as follows.

Bits 3 to 0 in byte 112 shall be bits 11 to 8 of the disk manufacturer code.

Bits 7 to 0 in byte 113 shall be bits 7 to 0 of the disk manufacturer code.

Bytes 114 to 115 shall be reserved and set to (00h).

Bytes 116 to 127 shall be the disk serial number.

Bytes 128 to 2 047

These bytes shall be reserved and set to (00h).

Bytes 2 048 to 4 097: Copy of Anchor volume descriptor pointer

The Anchor Volume Descriptor Pointer contains three things of interest:

1. Static structures that may be used to identify and verify integrity of the disc.
2. Location of the Main Volume Descriptor Sequence
3. Length of the Main Volume Descriptor Sequence

Bytes 4 098 to 61 439

These bytes shall be reserved and set to (00h).

Bytes 61 440 to 61 441: Vendor code

These bytes shall specify vendor code in ASCII characters, specified in ECMA-94.

Bytes 61 442 to 65 535: vendor-specific information 1

These bytes are used for vendor-specific information.

The media ID structure shall be as shown in Figure 9.

Relative byte position	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Remarks
0	Reserved				(MSB)				
1	Manufacturer code (LSB)								
2 to 3	Reserved								
4 to 15	(MSB) Disk serial number (LSB)								

Figure 9 — Media ID structure

7.2.3 Info area

7.2.3.1 General

The Info area structure is different between non-parity disk type and parity disk type.

7.2.3.2 Info area structure for parity disk type

The size of Info area can be selected by user and shall not be changed after formatting (see Clause 7.1).

The Info area structure shall be as shown in Figure 10. The latest Info data shall be recorded to Disk1 and Disk5. Info data shall consist of the parallel read/write mode identifier, its revision number, and VAT logical block address.

	Info area			
Disk1	...	Info data at one before the latest	Latest Info data	Unrecorded
Disk2	...	Temporal parity at one before the latest	Latest temporal parity	Unrecorded
Disk3	...	Temporal parity at one before the latest	Latest temporal parity	Unrecorded
Disk4	...	Temporal parity at one before the latest	Latest temporal parity	Unrecorded
Disk5	...	Info data at one before the latest	Latest Info data	Unrecorded

Figure 10 — Info area structure for parity disk type

7.2.3.3 Info data for parity disk type

Info data shall be recorded to the next logical cluster of the last recorded logical cluster at the Info area on Disk1 and Disk5 at each packet, as shown in Figure 10.

The Info data structure for the parity disk type shall be as shown in Figure 11.

The logical block address of VAT shall be recorded in order to detect previously recorded data easily, even if the current data recording fails.

Relative byte position	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
0 to 31	(MSB) Parallel read/write identifier and revision number (LSB)							
32 to 35	(MSB) VAT logical block address (LSB)							
36 to 47	Reserved							
48 to 51	(MSB) Objective logical cluster number (LSB)							
52 to 55	Reserved							
56	Last recorded disk number							
57	Temporal parity indicator							
58 to 32 767	Reserved							
32 768 to 65 535	Vendor-specific information 2							

Figure 11 — Info data structure for parity disk type

Bytes 0 to 31: Parallel read/write identifier and revision number

These bytes shall contain “R-Format-Information Rev1.0” in ASCII characters, specified in ECMA-94. Any other setting is prohibited in this Ecma Standard.

Bytes 32 to 35: VAT logical block address

These bytes shall contain the latest VAT logical block address in hexadecimal.

Bytes 36 to 47

These bytes shall be reserved and filled with (00h).

Bytes 48 to 51: Objective logical cluster number

These bytes shall contain the objective logical cluster number in hexadecimal.

Bytes 52 to 55

These bytes shall be reserved and filled with (00h).

Bytes 56: Last recorded disk number

This byte shall be the last recorded disk number in hexadecimal: (01h) to (04h).

Bytes 57: Temporal parity indicator

This byte shall be set as follows.

(00h): Temporal parity is invalid.

(FFh): Temporal parity is valid.

Any other setting is prohibited in this Ecma Standard.

NOTE: A setting of (00h) means that the objective logical cluster number and the logical recorded disk number are invalid.

Bytes 58 to 32 767

These bytes shall be reserved and filled with (00h).

Bytes 32 768 to 65 535: Vendor-specific information 2

These bytes are used for vendor-specific information

7.3 UDF management area

The UDF management area shall be formatted for packet writing mode and shall be recorded so as to satisfy UDF 1.5. User data shall be recorded to each UDF management area on Disk1 through Disk4. The logical block address shall be from 32 x *k* + 672 to N. Parity for each logical cluster on Disk1 through Disk4 shall be recorded at the same logical cluster on Disk5.

The recording order of the divided recording data shall be as specified below.

1) Logical cluster 0 in the UDF management area on Disk1

2) Logical cluster 0 in the UDF management area on Disk2

3) Logical cluster 0 in the UDF management area on Disk3

4) Logical cluster 0 in the UDF management area on Disk4

5) Logical cluster 1 in the UDF management area on Disk1

6) Logical cluster 1 in the UDF management area on Disk2

7) Logical cluster 1 in the UDF management area on Disk3

8) Logical cluster 1 in the UDF management area on Disk4

9) …

In Figure 12, each column is a logical cluster set.

	Logical cluster								
	0	1	2	3	4	5		n-1	
Disk1	1	5	9	13	17	21		n x 5 +1	
Disk2	2	6	10	14	18	22		n x 5 +2	
Disk3	3	7	11	15	19	23		n x 5 +3	
Disk4	4	8	12	16	20	24		n x 5 +4	
Disk5	P0	P1	P2	P3	P4	P5		P(n-1)	

Figure 12 — Recording order of divided recording data for parity disk type

7.4 Parity disk

When parity is applied, the parity disk shall be Disk5. Parity for each logical cluster on Disk1 through Disk4 shall be recorded at the same logical cluster on Disk5.

If the logical cluster on Disk4 is recorded, the parity shall be recorded to Disk5. The parity shall be generated according to the following formula.

bit x = (bit x of Disk1) XOR (bit x of Disk2) XOR (bit x of Disk3) XOR (bit x of Disk4)

If the last logical cluster in a packet is not recorded on Disk4, temporal parity shall be recorded because the parity is not defined.

7.5 Temporal parity

When the last logical cluster in a packet is not recorded on Disk4, temporal parity shall be recorded to the next logical cluster of the last recorded logical cluster in the info areas on Disk2, Disk3, and Disk4. The temporal parity shall be generated according to the following formulas.

When the last recorded disk is Disk3,

bit x = (bit x of Disk1) XOR (bit x of Disk2) XOR (bit x of Disk3)

When the last recorded disk is Disk2,

bit x = (bit x of Disk1) XOR (bit x of Disk2)

When the last recorded disk is Disk1,

bit x = bit x of Disk1

If the last logical cluster in a packet is recorded on Disk4, the temporal parity areas on Disk2, Disk3, and Disk4 shall be filled with (00h).

8 Signal quality of the recorded data

The signal quality of recorded data shall satisfy each physical format standard or specifications.

Annex A
(informative)

How to implement write/read operations

A.1 System structure

Figure A.1 shows a block diagram of the overall system configuration including the host and system. The host consists of application software, an operation system, a file system and a proprietary device driver. The system consists of system control firmware, Drive1, Drive2, Drive3, Drive4, and Drive5. The proprietary device driver enables the host to recognize five drives as a single drive. The proprietary device driver controls the five drives to record the data.

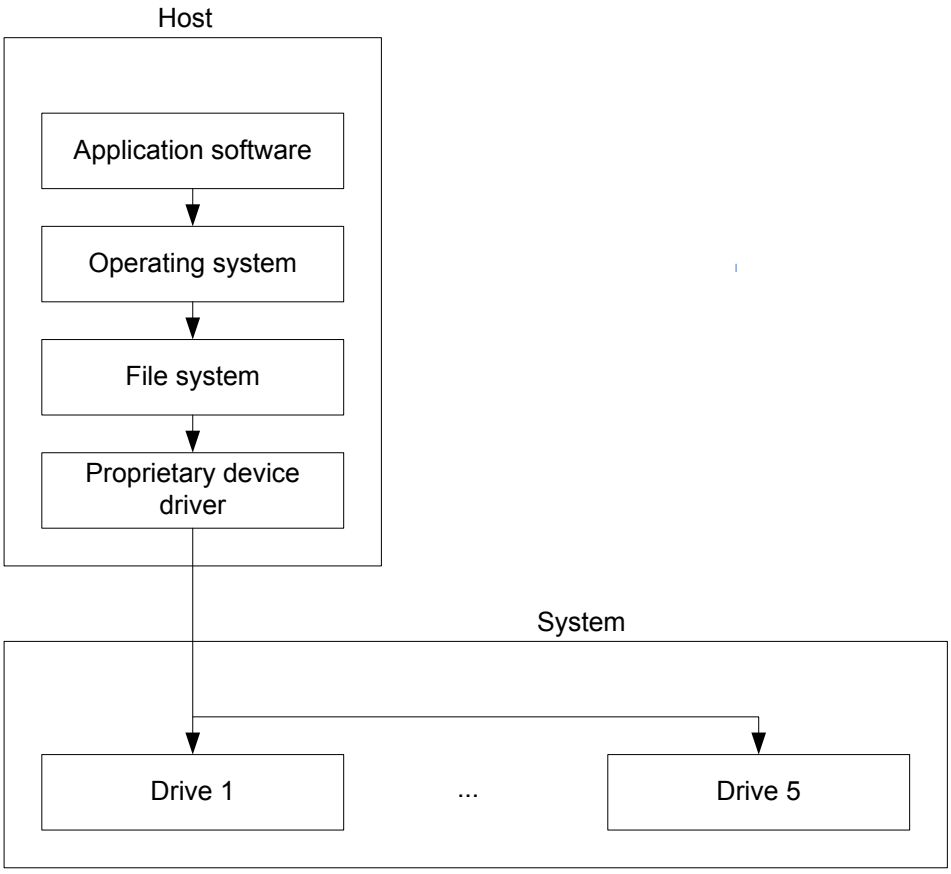

Figure A.1 — Block diagram of system configuration

A.2 Non-parity disk type

A.2.1 Flow of data recording operations

Figure A.2 shows a flow chart for data recording operations.

When the media set is inserted into the system, the file system requests the remaining recordable data capacity and the last recorded logical block address from the proprietary device driver. The proprietary device driver acquires the remaining recordable data capacity of the 5 disks and the last recorded logical cluster set number and calculates the total remaining recordable data capacity and the last recorded logical block address. Then, the proprietary device driver returns the total remaining recordable data capacity and the last recorded logical block address to the file system.

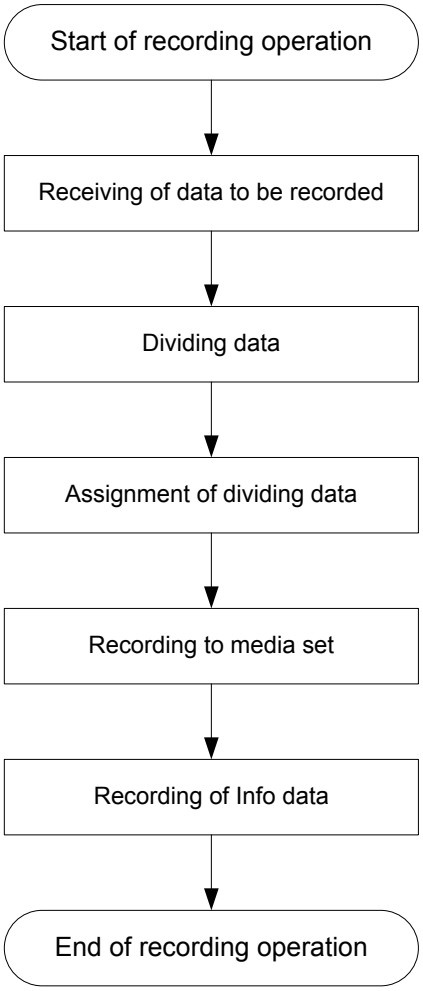

Figure A.2 — Flow chart of data recording operations for non-parity disk type

1) Receiving data to be recorded

The proprietary device driver receives data to be recorded from the file system of the host.

2) Dividing data

The proprietary device driver divides the data from the host and makes multiple divided recording data in order to record the data to each disk. The proprietary device driver divides the data into multiple divided recording data blocks. The divided recording data block size is 64 kbytes. Here, the total number of divided recording data block is n and the divided recording data blocks are D1-1, D1-2, …, D1-n.

3) Assignment of dividing data

The file system requests the recordable logical block address from the proprietary device driver.

The proprietary device driver acquires the recordable logical clusters of 5 disks and calculates the last disk. Then, the proprietary device driver returns the recordable logical block address converted from the recordable logical clusters of the last disk of the 5 disks to the file system.

The file system sends the start recording logical block address to the proprietary device driver. The proprietary device driver calculates which logical cluster of 5 disks should be recorded to first; in other words, it determines the start disk and its start logical cluster.

The proprietary device driver assigns the multiple divided recording data blocks continuously to the start logical cluster and the start disk in the recordable area.

The hatched part in Figure A.3 shows an example of logical clusters with data already recorded. In Figure A.3, the last recorded logical cluster number is i+1, the last recorded disk is Disk1, and the top disk is Disk2. The recording data D1 are assigned from the logical cluster number i+1 on Disk2 to the logical cluster number i+3 on Disk1.

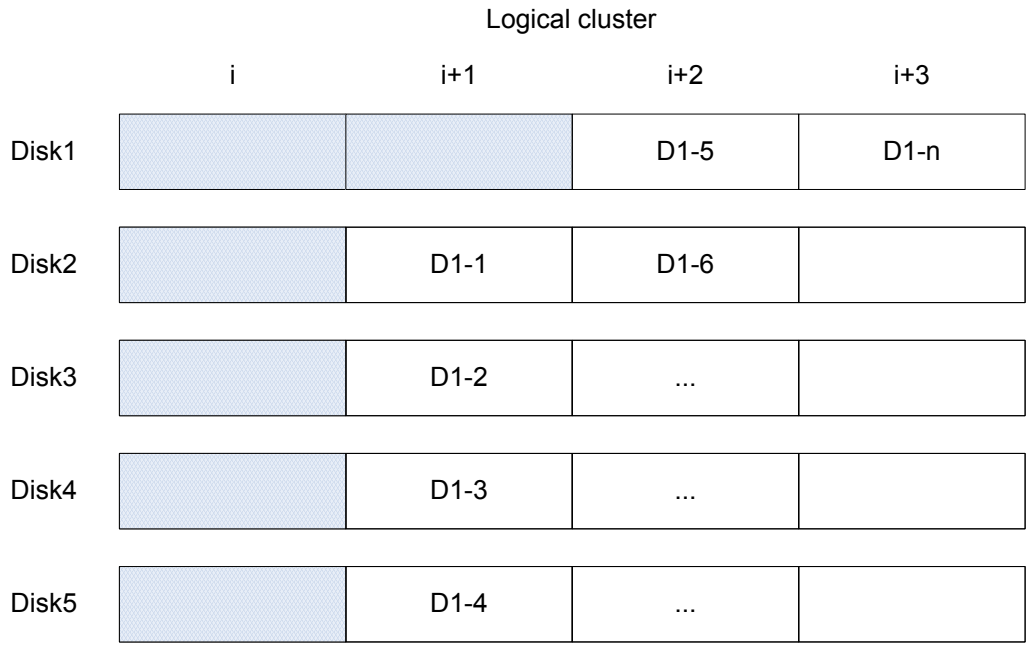

Figure A.3 —Example of recording allocation on disks

4) Recording to media set

The proprietary device driver orders recording of an assigned divided recording data block to each drive. According to this operation, each drive records the assigned divided recording data block to each disk. Parallel data recording is done as a result.

5) Recording of Info data

The proprietary device driver orders the parallel read/write identifier and VAT logical block address to be recorded in the Info area on each of the multiple disks when the proprietary device driver receives “disk unload” command or the user interruption.

A.2.2 Data reproduction

When a media set is loaded, the file system requests the remaining data capacity and the last recording address. The proprietary device driver calculates the total remaining data capacity and the last recording address using the remaining data capacity of the 5 disks and the last recording address. The proprietary device driver returns to the file system the remaining data capacity and the last recording address.

Calculation of information for objective data

When the file system requests data reproduction, the proprietary device driver calculates the following information for the objective data in the media set from the logical block address and its size required by the file system.

1) Start reading logical cluster set number

2) Start reading disk number

3) Last reading logical cluster set number

4) Last reading disk number

Data reproduction

Data are reproduced according to the above address information. The data are recorded in units of logical clusters as shown in Figure A.3; therefore the proprietary device driver orders D1-1, D1-2, D1-3, D1-4, D1-5, and D1-6 to be read and connects the data as shown in Figure A.4.

The proprietary device driver sends data requested by the file system.

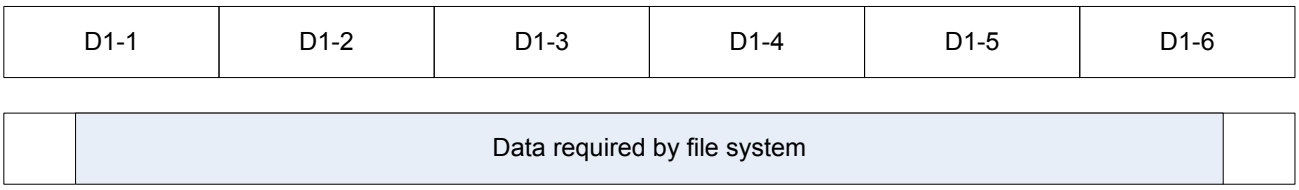

Figure A.4 —Example of data composition

A.3 Parity disk type

A.3.1 Flow of data recording operations

Figure A.5 shows the flow chart for data recording operations.

When the media set is inserted into the system, the file system requests the remaining recordable data capacity and the last recorded logical block address from the proprietary device driver. The proprietary device driver acquires remaining recordable data capacity of 4 disks except for the parity disk and the last recorded logical cluster set number, and calculates the total remaining recordable data capacity and the last recorded logical block address. Then, the proprietary device driver returns to the file system the total remaining recordable data capacity and the last recorded logical block address.

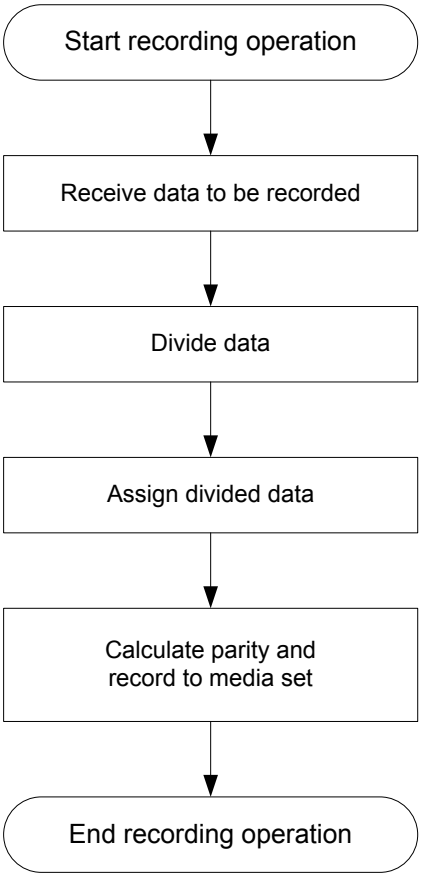

Figure A.5 — Flow chart for data recording operations for parity disk type

A.3.1.1 Receiving data to be recorded

The proprietary device driver receives data to be recorded from the file system of the host.

A.3.1.2 Dividing data

The proprietary device driver divides the data received from the file system and makes multiple divided recording data in order to record to each disk. The proprietary device driver divides the data among multiple divided recording data blocks. The divided recording data block size is 64 kbytes. Here the total number of divided recording data block is n and divided recording data blocks are D1-1, D1-2, …, D1-n.

A.3.1.3 Assignment of dividing data

The file system requests the recordable logical block address from the proprietary device driver.

The proprietary device driver acquires the recordable logical clusters of 5 disks and calculates the last disk. Then the proprietary device driver returns to the file system the recordable logical block address converted from the recordable logical clusters of the last disk of the 5 disks.

The file system sends the start recording logical block address to the proprietary device driver. The proprietary device driver calculates which logical cluster of the 5 disks should be recorded at first; in other words, it determines the start disk and its start logical cluster.

The proprietary device driver assigns the multiple divided recording data blocks continuously to the start logic cluster number and the start disk in recordable area.

The hatched part in Figure A.6 shows an example of logical clusters with data already recorded. In Figure A.6, the last recorded logical cluster number is i+1, the last recorded disk is Disk1, and the start disk is Disk2. The recording data D1 are assigned from the logical cluster number i+1 on Disk2 to the logical cluster number i+3 on Disk1.

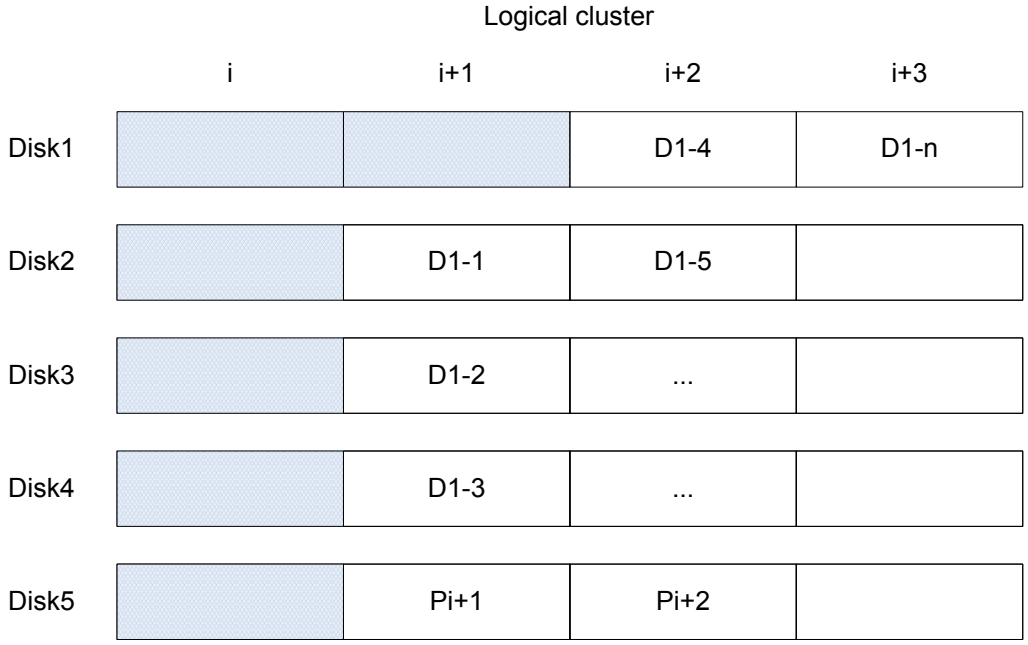

Figure A.6 —Example of recording allocation on disks

A.3.1.4 Parity calculation and recording to media set

Figure A.7 shows the parity recording process.

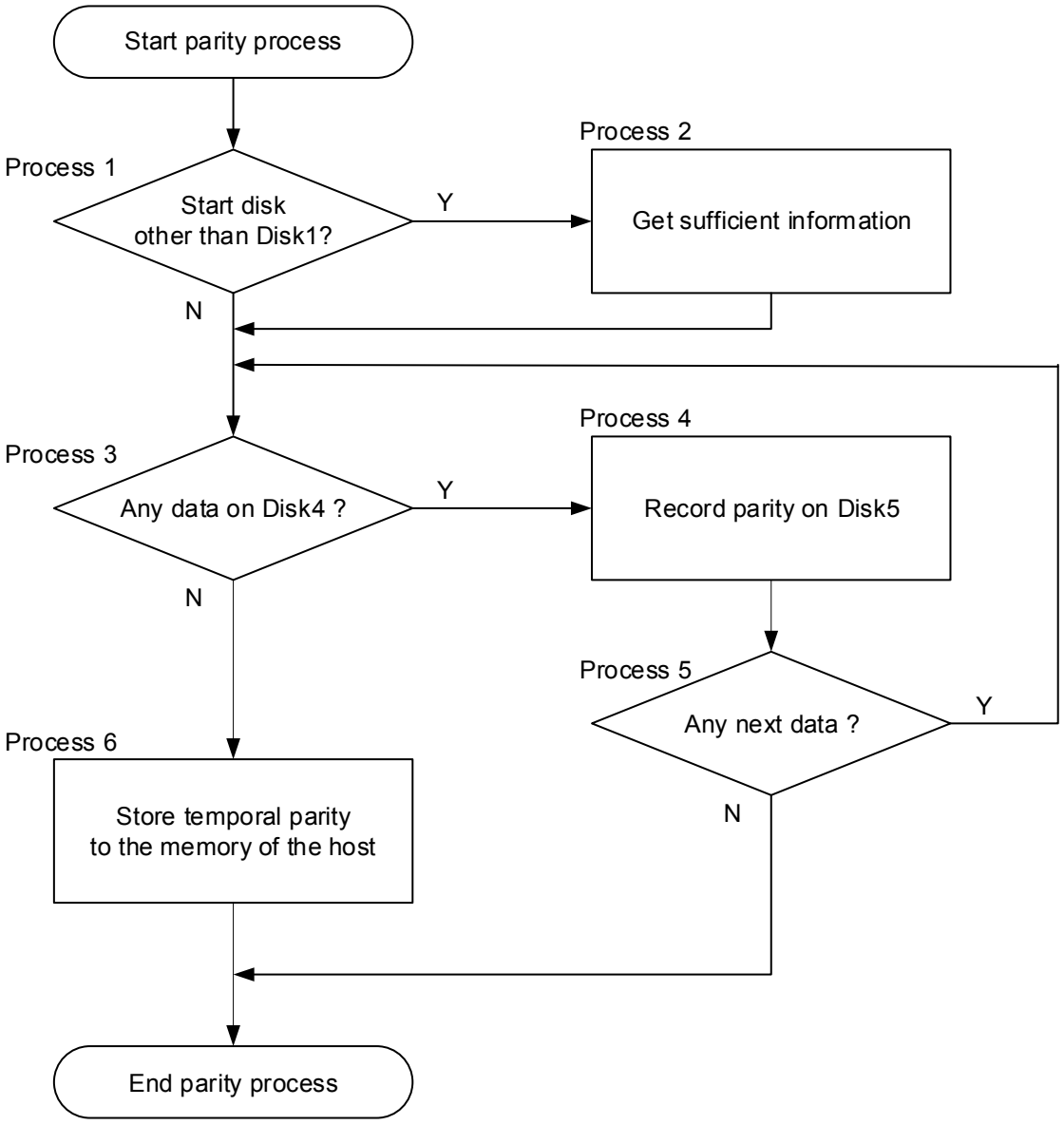

Figure A.7 — Parity recording process

Below is an explanation of the parity recording process for recording data from D2-1 to D2-n when the data are recorded with D1-n.

Process 1 and Process 2:

The aim is to determine whether the start disk is a disk other than 1.

If the start disk is a disk other than, sufficient information is obtained (e.g., the logical cluster set number x in Figure A.8).

Process 3:

The aim is to check whether the objective cluster on Disk4 is already recorded.

Process 4:

If the objective cluster has already been recorded (e.g., the logical cluster x in Figure A.8), then the proprietary device driver orders parity to be recorded on Disk5.

Process 5:

If the next logical cluster exists (e.g., the logical cluster set number x+1 in Figure A.8), then go to process 3.

If the next logical cluster does not exist (e.g., the logical cluster set number x+1 in Figure A.9), then go to end parity process.

Process 6:

When the objective cluster on Disk4 is not recorded (e.g., the logical cluster y in Figure A.8), the proprietary device driver calculates the temporal parity and requests the host to store the temporal parity to the memory of the host.

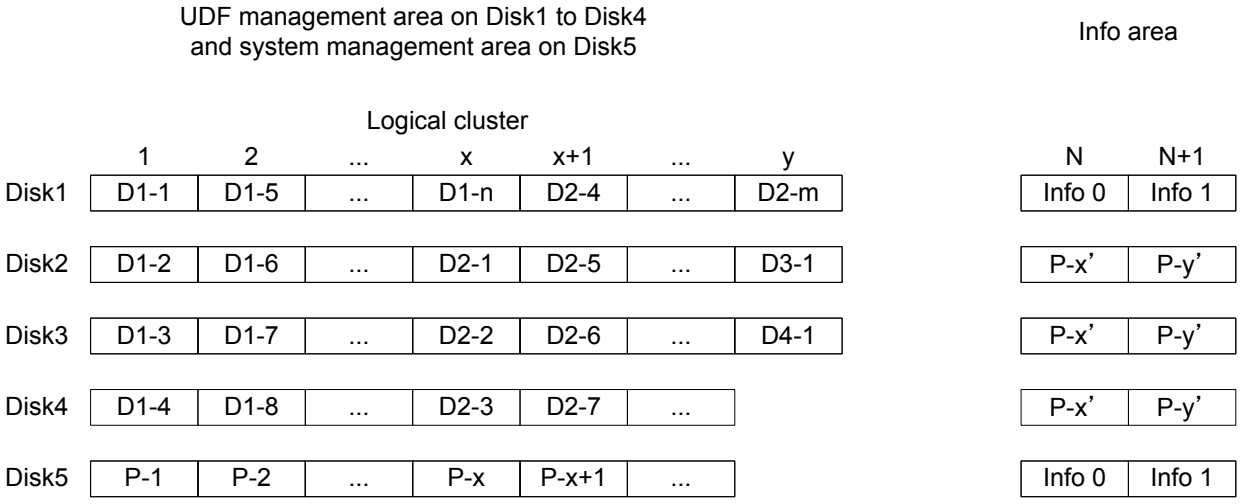

Figure A.8 — Parity and temporal parity when the next logical cluster exists

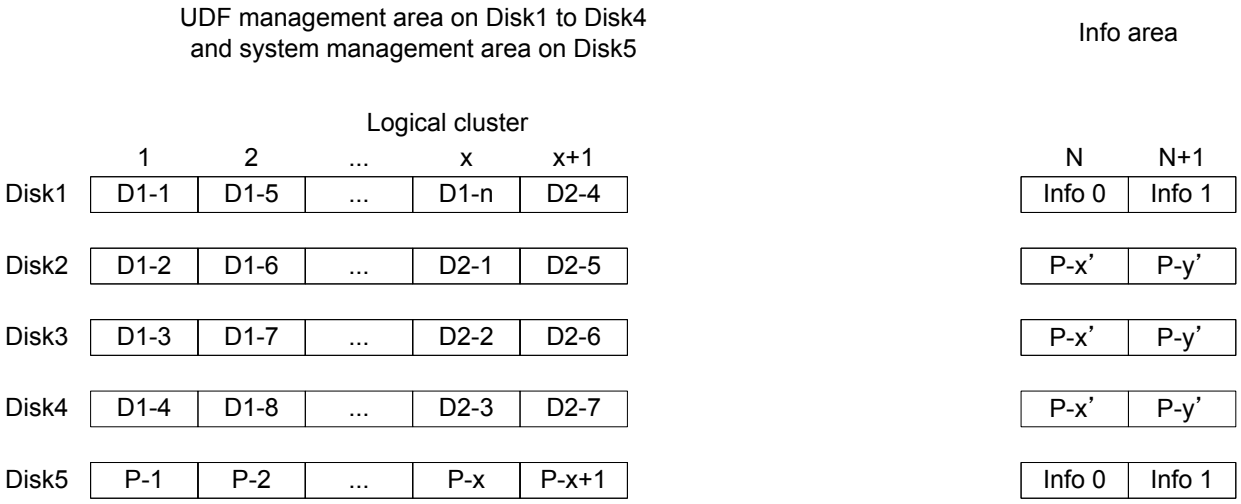

Figure A.9 — Parity and temporal parity when the next logical cluster does not exist

A.3.1.5 Recording to the media set

The proprietary device driver orders recording of assigned divided recording data block to each drive. According to this operation, each drive records the assigned divided recording data block to each disk.

A.3.2 Data reproduction for parity disk type

Figure A.10 shows the data reproduction process for the parity disk type.

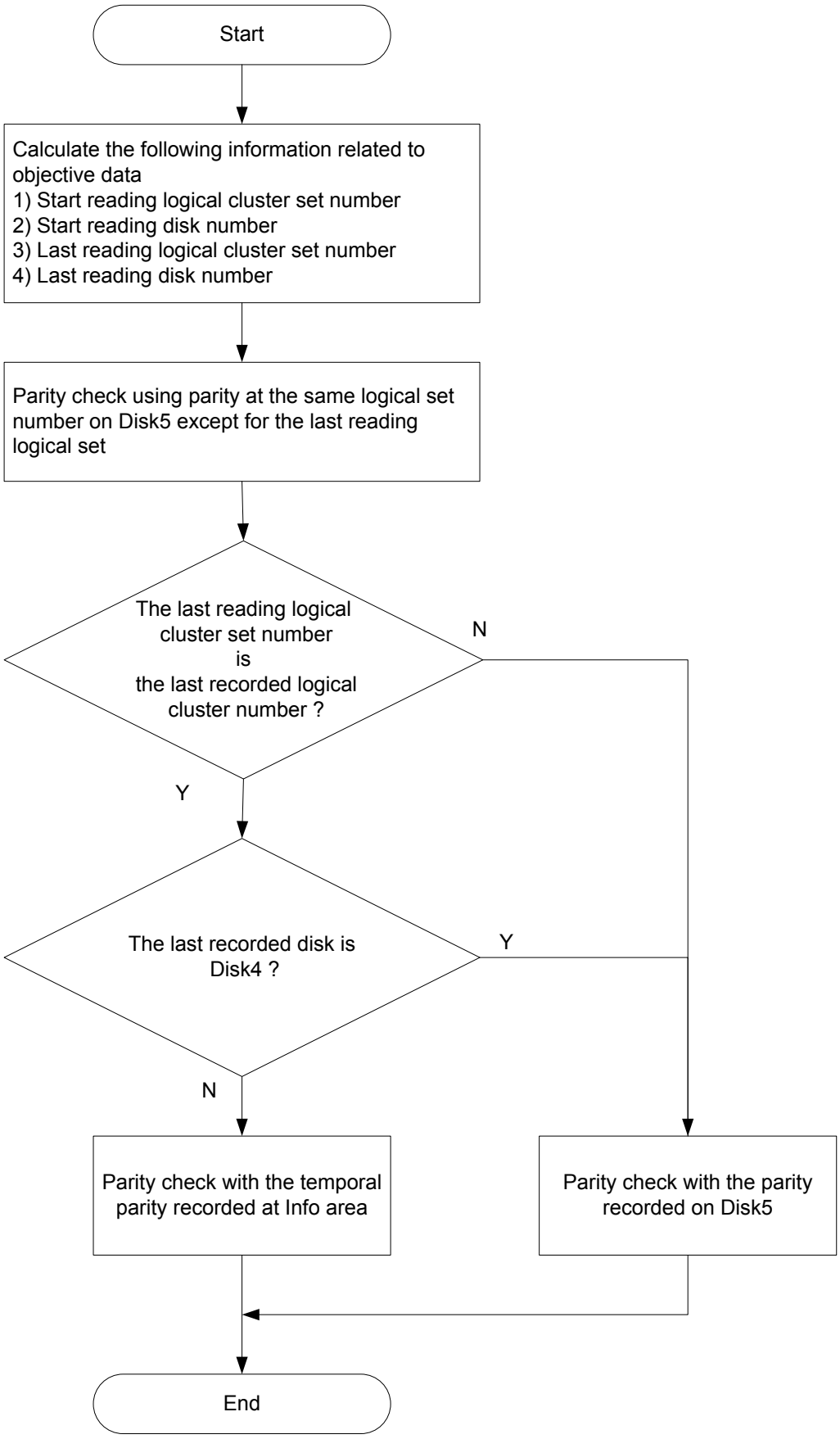

Figure A.10 — Data reproduction process for the parity disk type

A.3.2.1 Calculation of information for objective data

When the file system requests data reproduction, the proprietary device driver calculates the following information for the objective data in the media set from the logical block address and its size requested by the file system.

1) Start reading logical cluster set number

2) Start reading disk number

3) Last reading logical cluster set number

4) Last reading disk number

A.3.2.2 Parity check for recorded data except for the last reading logical cluster set

The proprietary device driver checks parity using the parity recorded on Disk5 except for the last reading logical cluster set.

A.3.2.3 Parity check for recorded data for the last reading logical cluster set

When the last reading logical cluster set number x is smaller than the last recorded logical cluster number in the media set, the proprietary device driver checks parity with the parity P-x (see Figure A.11).

If the last reading logical cluster set number y is the same as the last recorded logical cluster number in the media set and also if the last recorded disk is Disk4, the proprietary device driver checks parity with the parity recorded on Disk5 (see Figure A.11).

If the last reading logical cluster set number y is the same as the last recorded logical cluster number in the media set and also if the last recorded disk is not Disk4, the proprietary device driver checks parity with the temporal parity P-y' recorded in the info area (see Figure A.8).

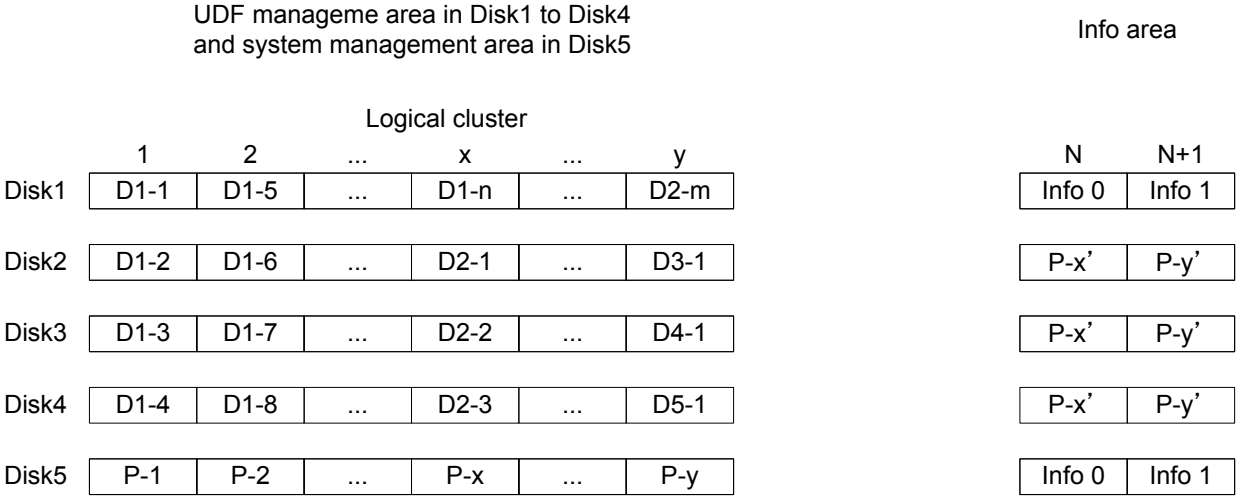

Figure A.11 — Parity statement when the last recorded disk is Disk4

A.3.2.4 Data reproduction

Data are reproduced according to the above address information described in A.3.2.1. The data are recorded in units of logical clusters, as shown in Figure A.6, therefore the proprietary device driver orders D1-1, D1-2, D1-3, D1-4, and D1-5 to be read and connects the data as shown in Figure A.12.

The proprietary device driver sends the data requested by the file system.

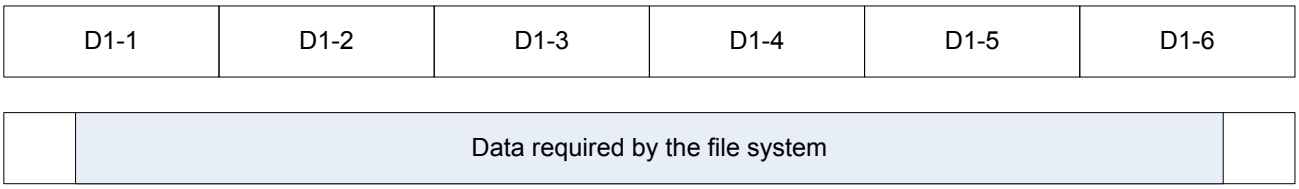

Figure A.12 —Example of data composition

A.4 Treatment of data recording fails

If the data recording fails such as the electric power source down, disconnecting of cables between the system and the host, occurred during the data recording, the optical disk drives usually can not recognize the disks even though the user turns the electric power or connects cables between the system and the host again.

Although the data recording fails occurred, the proprietary device driver can read the VAT logical block address recorded before the data recording fails and the VAT information. Therefore the system can reproduce the data recorded before the data recording fails.

Annex B
(informative)

Address conversion

The logical block address number *X* operated by the file system in decimal is converted to the disk number, the logical cluster set number on each disk, and the logical block address number on each disk in accordance with the following formulas.

Disk number:

Int(mod(*X*, 4 x 32)/32) + 1

Logical cluster set number on each disk:

Int(*X* / (4 x 32)) + *k* +21,

Logical block address number on each disk:

mod (*X*, 32) + INT (*X* / (32 x 4)) x 32 + 32 x (*k* + 21)

Here, *k* is the logical cluster number of the info area that the user selects.

Address conversion from the logical block address number *Y* on each disk and the disk number *Z* to the logical block address number operated by the file system is done by using the following formulas

Logical block address number operated by the file system:

INT (*Y* – 32 x (*k*+21)) / 32) x 32 x 4 + (*Z* -1) x 32 + mod(*Y*, 32)

Here, *k* is the logical cluster number of the info area that the user selects.

Bibliography

[1] ISO/IEC 30190:2013, Information technology – Digitally recorded media for Information interchange and storage – 120 mm Single Layer (25,0 Gbytes per disk) and Dual Layer (50,0 Gbytes per disk) BD Recordable disk

[2] ISO/IEC 30191:2013, Information technology – Digitally recorded media for Information interchange and storage – 120 mm Triple Layer (100,0 Gbytes per disk) and Quadruple Layer (128,0 Gbytes per disk) BD Recordable disk

[3] System Description Blu-ray Disc™ Recordable Format Part 1 Basic Format Specifications Version 1.3 April 2008, Blu-ray Disc Assocation

[4] System Description Blu-ray Disc™ Recordable Format (BDXL™) Part 1 Basic Format Specifications Version 2.0 June 2010, Blu-ray Disc Assocation

[5] OSTA Universal Disk Format™ Specification Revision 2.01:2000

[6] JIS X 0611:2012 Universal Disk Format (UDF) 2.01

NOTE JIS X 0611 is described in only Japanese.