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Overview of Universal Archive Disk Format (UADF)

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Introduction

To date, many kinds of storage media and storage devices for digital data storage have been used. For example, flexible disk, optical disk, magnetic tape cartridge, secure digital (SD) card, flash drive, hard disk drive (HDD), solid state drive (SSD), etc. Each of them has different characteristics in terms of volatility, mutability, accessibility, and addressability, where different management methods for recorded data files and different systemization technologies are applied. However, it is not easy to manipulate the characteristics properly, especially in personal, home and small office environments. As a result, many files recorded on storage media in the past cannot be recovered due to media age, digital rights management (DRM), compatibility between PC and drive interfaces, drives and media, operation systems (OS) and file systems, applications and file formats, and so on, making storage media unusable. This situation will continue for future generations.

This Technical Report describes the necessary perspectives to solve the problems of file system compatibility and also the age of the media and DRM by specifying a volume and file structure for interchanging files in a data archive system capable of preserving data for the long term.

This Ecma Technical Report was developed by Technical Committee 31 and was adopted by the General Assembly of December 2022

Overview of Universal Archive Disk Format (UADF)

1 Scope

This Technical Report describes the necessary perspectives for considering a universal volume and file format for interchanging files on archive storages in personal computing and home entertaining environment.

2 References

There are no normative references in this Technical Report.

3 Terms and definitions

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

3.1
space
physically contiguous region

3.2
volume
physically or logically contiguous *space* (3.1) where file system operates

3.3
physical volume
storage device (3.15) like HDD or SSD, or *disk* (3.16) like optical disk delivering single *space* (3.1) or plural *spaces* (3.1)

NOTE A single space is provided with no partitioning and plural spaces are provided with partitions, for example 128 in GUID partition table (GPT) format.

3.4
physical partition
contiguous *space* (3.1) created by partitioning a *physical volume* (3.3)

3.5
logical volume
logically contiguous region as a *volume* (3.2) consisted of *physical volumes* (3.3)

3.6
multi-volume
region consists of more than one *volume* (3.2)

3.7
operational volume
volume (3.2) assigned to a file system to work

3.8
container
mother *volume* (3.2) contains several logically distinguished contiguous regions as an *operational volume* (3.7) but sharing mother space to expand a logically contiguous region of the *operational volume* (3.7) on the fly until it reaches to the maximum size defined in the initial setting

3.9
expandable operational volume
logical volume (3.5) consisting of an initial physical region allocated and expanded on the fly with the addition of physically contiguous *segments* (3.10) in the mother *container* (3.8) until it reaches the maximum size that was initially set

3.10
segment
contiguous fixed size unit of a region for expanding an *expandable operational volume* (3.9)

3.11
long allocation descriptor
long_ad
16-byte data structure consisting of length and location fields of extent, which is a set of sectors or logical blocks, and implementation use field

NOTE The long_ad is intended for use when the extent's location may be on another partition (either on this volume or another).

3.12
ISO file
single file that's a perfect representation of an entire CD, DVD, or BD

NOTE The entire contents of a disk can be precisely duplicated in a single ISO file based on ECMA-119 or ECMA-167.

3.13
column wise system file
system file for applying vertical division data of row table data

3.14
universal archive disk format
UADF
universal volume and file format for interchanging files on archive storages

3.15
storage device
functional unit into which data can be placed, in which they can be retained, and from which they can be retrieved storage

3.16
disk
circular storage in which data are stored on the flat surfaces, in use, rotating around a spindle

4 Abbreviations

API application programming interface

A/V audio and visual

DRM digital rights management

Exif exchangeable image file format

GUI	graphical user interface
HDD	hard disk drive
ICT	information and communication technology
iVDR	information versatile disk for removable usage
LVM	logical volume manager
OS	operating system
PE	physical extent
QBE	query-by-example
RAID	redundant arrays of inexpensive disks
SD card	secure digital card
SSD	solid state drive
UADF	universal archive disk format
UDF	universal disk format
VG	volume group

5 Current situation for data recorded on media

There is a wide variety of storage media with the evolution of digital technology, and their management methods of recorded files are also diverse and inconsistent. Each storage medium has different characteristics, but most users don't have any knowledge about them, and even if they have it, it is not easy to manipulate the characteristics properly, especially for personal, home, and small offices. As a result, many of the files recorded on storage media in the past are presently difficult to restore. For example, it is difficult to retrieve files from old HDDs due to the age of the devices and the connectivity of their interface, from flexible disks and SmartMedia due to the age of the media and devices and the compatibility of their file systems. Also, due to the manufacturer's proprietary DRM that relies on individual devices, it is impossible to play video contents from HDDs connected to, for example, another TV.

It can be easily expected for this situation to continue in the future.

6 Data archive system

6.1 General

It is desirable that:

- all storage devices of various types that make up the data archive system are treated as one storage system and users don't need to consider data allocation on it;

- In order to have a flexible, powerful and robust data archive system, all created data such as documents, photos, videos, and recorded television (TV) contents with digital rights management (DRM), are stored in an appropriate storage automatically and managed easily with minimized storage reallocation; all data stored in the lost storage devices are retrieved completely even if some of the storage devices that make up the data archive system are broken or missing; and privacy and security of the data are protected from ransomware by using proper encryption technologies.

It should be considered to specify a volume and file structure for interchanging files in a data archive system to allow for any people to archive data easily and safely for long term.

6.2 File rearrangement for archived data

To specify a tool to assist the rearrangement of existing files to transfer to the data archive system.

To specify a guideline to arrange OS data, OS user specific data and user specific data.

To avoid user confusion with various types of volumes.

To define terms in an intuitive and easy way so they are understood in a top-down approach.

6.3 Digital rights management (DRM)

To specify hardware and software system architectures of the data archive system and introduce proprietary DRM system co-working together with the data archive system.

6.4 Data archive system integrated various media with high capacity, high performance, flexibility, and availability

To share an image of the data archive system to combine with a cloud data archive system and a data archive service with existing media in the site.

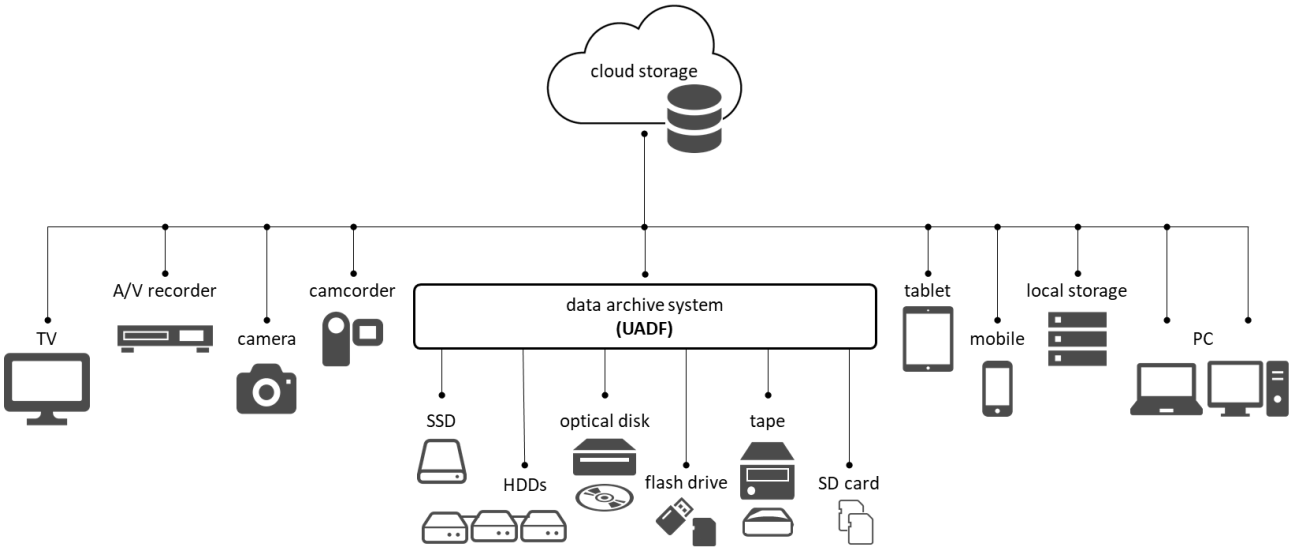

Figure 1 — Data archive system integrating various media

The data archive system supports, not only ICT equipment, such as a PC, a tablet, but also home entertainment equipment, such as an A/V recorder, a camcorder, etc.

All kind of storage devices, optical disk, HDD, tape, cloud storage, etc., which are connected to the user owned data archive system could be supported as the family storage and the location of data in the family is managed by the data archive system and the mirrors of the family storage could be stored in the data archive system with the directory information in the original location.

In general, each storage device is understood as follows:

- optical disk
  - used for content distribution & viewing and for data archiving;
  - relatively increasing usage as data archiving, because distribution of ISO file format which can be handled on PC is possible;
- HDD
  - used for general data storage;
  - keeping enlarging capacity and declining bit cost continuously;
  - operational life is unclear;
- SSD
  - used for general data storage;
  - keeping enlarging capacity and declining bit cost continuously;
  - also convenient for data archiving if bit cost is lowed and durability for retrieving recorded data is enhanced.

6.5 Query-by-example (QBE) style graphical user interface (GUI) for data archive system

To specify a file explorer with QBE-style GUI to assist data set processing easily.

6.6 External media management

To make it easier to manage the contents of the external drive.

6.7 Data security (safety and confidentiality)

To provide security features to the contents in the data archive system.

6.8 ISO file format for archived data

To encourage to the storage of a set of files as an ISO file that becomes read only.

6.9 Data deduplication

To prevent duplicating a file in the data archive system.

6.10 Data structure for data archive system

To provide feature to index contents in the data archive system.

7 File system for archived data

7.1 General

It is essential that a file system for the data archive system is smart, for example capable of recognizing any problem occurring in the system, informs about it and presents solutions to a user at an appropriate time. When a problem such as a playback issue of the content happens in the system, the file system requests to report the status to all layers from a user interface layer to a device layer of the system, but also to users in some cases. The file system resolves compatibility issues of past storage which frequently happen at home and in small offices, such as a file reading issue of flash drive or iVDR.

Additionally, to extend the capability of the file system, metadata corresponding to various types of files, such as Exif for photo related file, is introduced. It creates a new file management scheme using a set theory with a unique ID. The scheme enables to refer files as well as directories without path walk in file search.

These approaches create the digital papyrus platform that allows anyone to use any data easily and access to any data even in posterity.

7.2 Basic concept for data archive system

7.2.1 General

In the data archive system, various types of storage or storage devices, optical disk, HDD, tape, cloud storage, etc. which are connected to the user owned data archive system are supported as the family storage. The location of data in the family is managed by the data archive system and the mirrors of the family storage are stored in the data archive system with the directory information in the original location.

In order to make the system flexible, powerful and robust, all data created by the user location in the family storage are stored in an appropriate location in the data archive system when connected to the data archive system.

In the formulation of system standards, layered ideas are very helpful in organizing content and making it easy to understand. Therefore, many international standards related to information storage systems are defined by dividing them into layers.

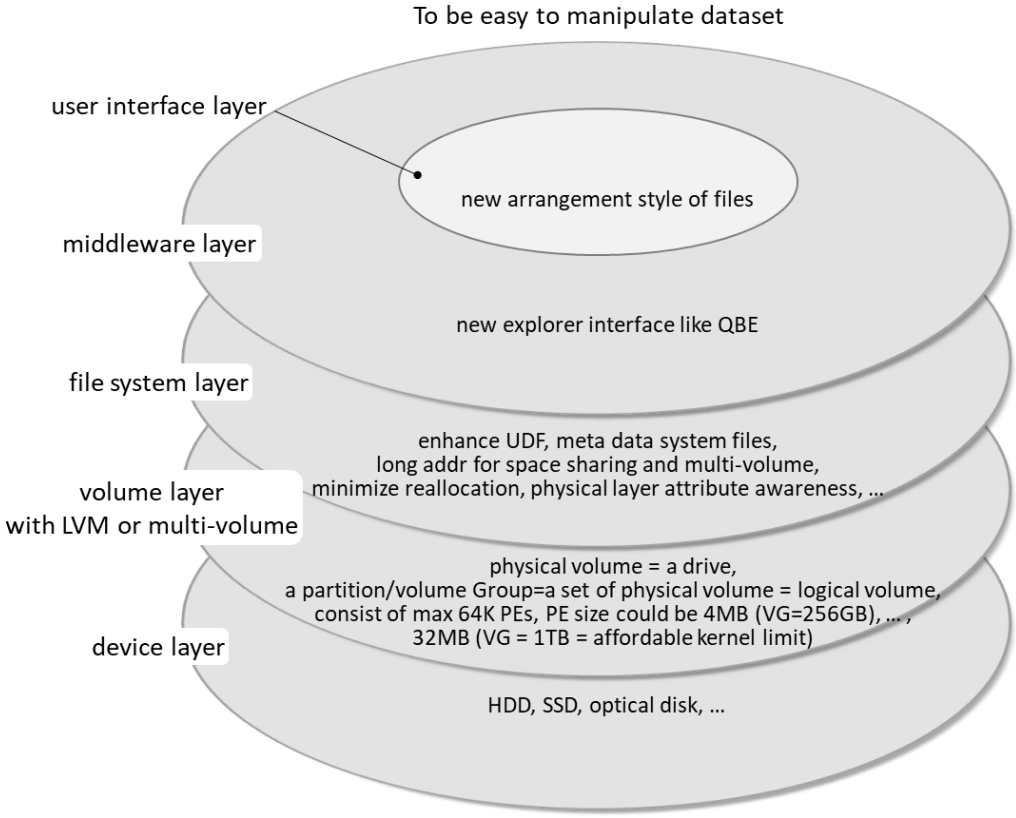

Figure 2 — Features to be implemented for each system layer

7.2.2 User interface layer

Even DRM managed, recorded TV contents or titles from other sources are managed by the data archive system. That means the DRM is controlled consistently with the certified portable key control device included in the data archive system.

The data in the cloud storage are synchronized with the data archive system in a smart way keeping consistency with the client storage.

The data archive system contains internal mirrors that enables the system to recover any data in the family storage.

The data archive system is capable to expand the system storage capacity by adding storage devices and/or replacing existing devices with larger ones.

The data archive system utilizes the best usage style for local storages, for example, SSD for metadata (directories) and hot contents data, HDD for hot and warm contents data, optical disks for cold metadata and contents data.

7.2.3 Middleware layer

In order to make it easier to handle set operations of massive data in the data archive system, a new exploring interface like QBE is indispensable.

To prepare a special sequential file for each metadata as a system file covering all files on the data archive system to provide the efficient set manipulation on the metadata.

An indexing scheme for semi-structured content files is necessary.

7.2.4 File System layer

For the file system of the data archive system, a space sharing feature is essential. Therefore, reconsideration of the volume and file structure of the data archive system from the basics is necessary. long_ad defined in ECMA-167 seems to be a unique feature to extend the logical volume size to be revisited.

To consider using UDF (refer to ECMA-167) as a base file system.

To use IEC 62842 to minimize reallocation of files in the data archive system.

To encourage user to convert a set of stable files to an ISO file.

7.2.5 Volume layer with LVM or multi-volume

LVM, which enables logical capacity expansion of a volume, and multi-volume, which is centred on a master volume, were developed for HDD and optical disk respectively.

LVM virtually connects multiple physical spaces to acquire a large space and can be easily adapted to HDD and SSD.

On the other hand, in a system using optical disks as a primary storage, where the physical space cannot be expanded, a single physical volume is the centre of the system, and other multiple physical volumes are added by serial numbers to belong to the main volume. The serial numbers are used to refer to another physical volume. This is an essential technology for extending the volume space logically called multi-volume.

Therefore, when building the system using optical disks as the primary storage, HDD and SSD connected to the system are divided into physical partitions with a capacity equivalent to the optical disk. The physical partitions are managed with the same volume size as the optical disk. A volume consisting of the required number of physical partitions is referenced to configure a multi-volume that can be referenced from the file system to secure a virtual large volume space.

To provide flexible capacity expansion of the system by using LVM or multi-volume, and to put redundancy support with RAID on it.

The long_ad of UDF is carefully enhanced to provide the space sharing of the volumes.

In order to assist the fast set manipulation for accessing files matching with the conditions specified by the user, column wise system files can be applied. The column wise system files are stored in the attribute data field of each file, and each stream file stores the attribute data value in the volume set in system stream files.

To encourage users and programmers to develop utilities and make utility development easier with the introduction of shell script and JavaScript API sets to develop file explorers.

To use a proper encryption technology and other technologies to protect from ransomware to protect data privacy and enhance data security.

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