IEC TR 63475

Edition 1.0 2023-11

TECHNICAL REPORT

Overwiew of Universal Archival Disk Format (UADF)

IEC TR 63475:2023-11(en)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC TR 63475

Edition 1.0 2023-11

TECHNICAL REPORT

Overwiew of Universal Archival Disk Format (UADF)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 35.220.30

ISBN 978-2-8322-7883-3

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

OVERVIEW OF UNIVERSAL ARCHIVE DISK FORMAT (UADF)

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 63475 has been prepared by technical area 6: Storage media, storage data structures, storage systems and equipment, of IEC technical committee TC 100: Audio, video and multimedia systems and equipment. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
100/4030/DTR	100/4065/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

To date, many kinds of storage media and storage devices for digital data storage have been used. For example, flexible disks, optical disks, magnetic tape cartridges, secure digital (SD) cards, flash drives, hard disk drives (HDD), solid-state drives (SSD). 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 document describes the significant 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.

OVERVIEW OF UNIVERSAL ARCHIVE DISK FORMAT (UADF)

1 Scope

This document describes a universal volume and file format for interchanging files on archive storages in personal computing and home entertainment environments.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
space
physically contiguous region

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

3.3
physical volume
storage device (3.15) such as HDDs or SSDs, or *disks* (3.16) such as optical disks delivering a single *space* (3.1) or multiple *spaces*

Note 1 to entry: 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) consisting 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) containing several logically distinguished contiguous regions as an *operational volume* (3.7), but sharing the mother *space* (3.1) to expand a logically contiguous region of the *operational volume* (3.7) on the fly until it reaches the maximum size defined in 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_ad
long allocation descriptor
16-byte data structure consisting of length and location fields of extent, which is a set of sectors or logical blocks, and an implementation use field

Note 1 to entry: The long_ad is intended for use when the extent's location may be on another partition (either on a given volume or another).

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

Note 1 to entry: The entire contents of a disk can be precisely duplicated in a single ISO file based on ISO 9660 or ISO/IEC 13346.

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

[SOURCE: ISO/IEC 2382-1:1993, 01.01.10]

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, and from floppy disks and SmartMedia due to the age of the media and devices and the compatibility of their file systems. Also, due to manufacturers' 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

A data archive system includes the following features:

– 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; privacy and security of the data are protected from ransomware by using proper encryption technologies.

Therefore, items listed in 6.2 through 6.10 are introduced in a volume and file structure for interchanging files in a data archive system to allow for any person to archive data easily and safely for the long term.

6.2 File rearrangement for archived data

File rearrangements include:

– a tool to assist the rearrangement of existing files to transfer to the data archive system;
– a guideline to arrange OS data, OS user-specific data and user-specific data;
– avoidance of user confusion with various types of volumes;
– terms in an intuitive and easy way so they are understood in a top-down approach.

6.3 Digital rights management (DRM)

DRM is a hardware and software system architecture of the data archive system and introduces proprietary DRM systems working together with the data archive system.

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

The data archive system is an image of the data archive system as shown in Figure 1 combining with a cloud data archive system and a data archive service with existing media in the site.

The data archive system supports not only ICT equipment, such as PCs, tablets, but also home entertainment equipment, such as A/V recorders and camcorders.

All kind of storage devices (optical disks, HDDs, SSDs, cloud storage, etc.), which are connected to the user-owned data archive system, could be supported as the household storage and the location of data in the household is managed by the data archive system and the mirrors of the household storage could be stored in the data archive system with the directory information in the original location.

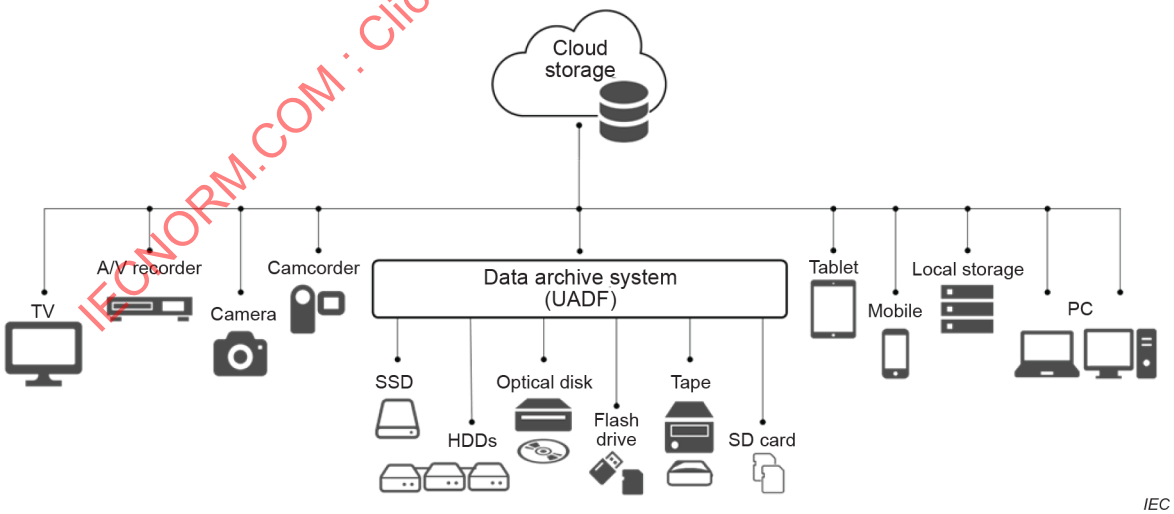

Figure 1 – Data archive system integrating various media

In general, each storage device is understood as follows:

– optical disk
  • used for content distribution and viewing, and for data archiving;

- its share of data archiving use is increasing because distribution of ISO file format which can be handled on PC is possible;

– HDD
  - used for general data storage;
  - their capacity is ever increasing and the cost per bit is declining;
  - operational life is unclear;

– SSD
  - used for general data storage;
  - their capacity is ever increasing and the cost per bit is declining;
  - also convenient for data archiving if bit cost is lowered and durability for retrieving recorded data is enhanced.

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

The GUI is a file explorer with QBE-style GUI to assist in processing the data set easily.

6.6 External media management

The external media management is a method to make it easier to manage the contents of the external drive.

6.7 Data security (safety and confidentiality)

Data security is a method providing security features to the contents in the data archive system.

6.8 ISO file format for archived data

The ISO file format is an encouragement for storing a set of files as an ISO file that becomes read-only.

6.9 Data deduplication

Data deduplication prevents duplication of identical files in the data archive system.

6.10 Data structure for data archive system

Data structure is a method providing 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 a flash drive or iVDRs.

Additionally, to extend capability of the file system, metadata corresponding to various types of files, such as Exif for photo-related files, 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, which enables permanent preservation of digital data.

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 disks, HDDs, tapes, cloud storage, etc. which are connected to the user-owned data archive system are supported as the household storage.

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, as shown in Figure 2.

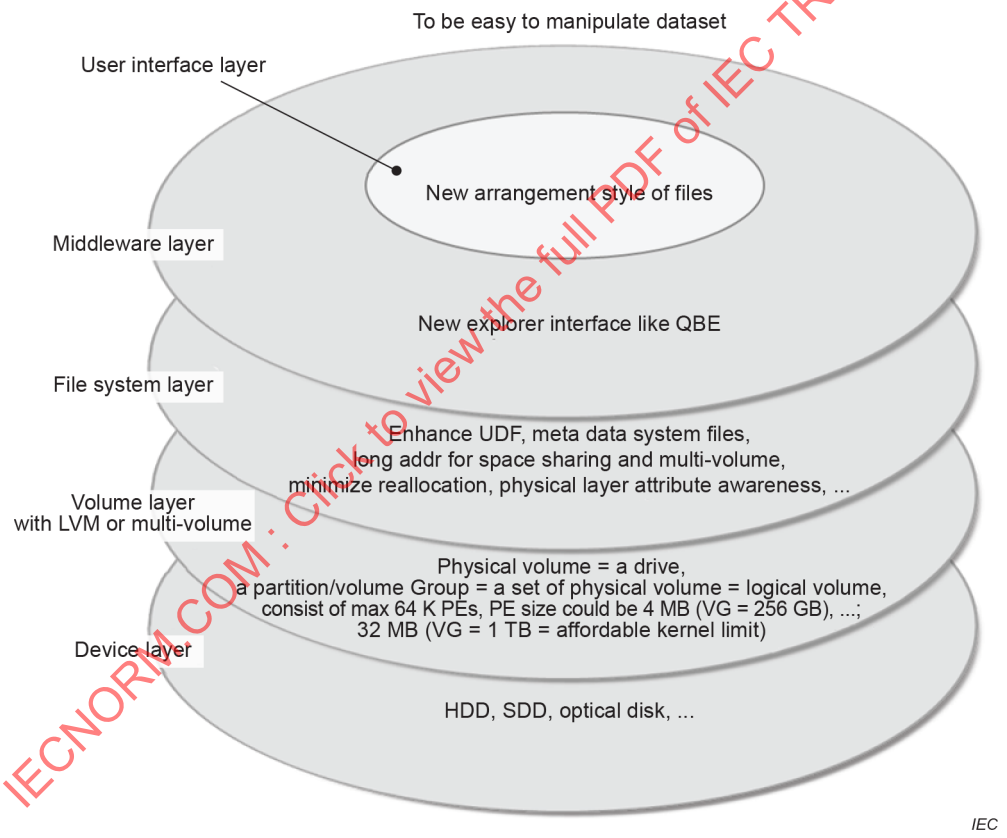

Figure 2 – Features to be implemented for each system layer

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 enable the system to recover any data in the family storage.

The system storage capacity of the data archive system can be expanded 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, SSDs for metadata (directories) and frequently accessed contents called hot data, HDDs for contents classified as hot or warm data, optical disks for cold data (i.e. rarely accessed metadata and contents).

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 a QBE is advantageous.

A special sequential file for each metadata, such as a system file covering all files on the data archive system, is introduced to provide the efficient set manipulation on the metadata.

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

7.2.4 File system layer

For the file system of the data archive system, a space-sharing feature is essential. Therefore, the volume and file structure of the data archive system from the basics is reconsidered under the following directions:

– consideration of using UDF (refer to ISO/IEC 13346) as a base file system;
– use of IEC 62842 to minimize reallocation of files in the data archive system;
– conversion of a set of stable files to an ISO file.

Long_ad defined in ISO/IEC 13346 seems to be a unique feature to extend the logical volume size to be revisited.

7.2.5 Volume layer with LVM and multi-volume

LVMs, which enables logical capacity expansion of a volume, and multi-volume, which is centred on a master volume, were developed for HDDs and optical disks, respectively.

LVMs virtually connect multiple physical spaces to acquire a large space and can be easily adapted to HDDs and SSDs.

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, HDDs and SSDs 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.

The capacity of the system by using LVMs or multi-volume is flexibly expanded, and redundancy is ensured by supporting 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 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.

Users and programmers are encouraged to develop utilities and make utility development easier with the introduction of shell script and JavaScript API sets to develop file explorers.

A proper encryption technology and other technologies are applied to protect from ransomware, protect data privacy, and enhance data security.

Bibliography

IEC 62842, *Multimedia home server systems – File allocation system with minimized reallocation*

ISO/IEC 2382-1:1993, *Information technology – Vocabulary – Part 1: Fundamental terms*

ISO/IEC 13346-1, *Information technology – Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange – Part 1: General*

ISO/IEC 13346-2, *Information technology – Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange – Part 2: Volume and boot block recognition*

ISO/IEC 13346-3, *Information technology – Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange – Part 3: Volume structure*

ISO/IEC 13346-4, *Information technology – Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange – Part 4: File structure*

ISO/IEC 13346-5, *Information technology – Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange – Part 5: Record structure*

ISO 9660, *Information processing – Volume and file structure of CD-ROM for information interchange*

ECMA-119, *Volume and file structure of CDROM for information interchange*

ECMA-167, *Volume and file structure for write-once and rewritable media using non-sequential recording for information interchange*

ECMA TR/111, *Overview of Universal Archive Disk Format (UADF)*

Universal Disk Format® Specification Revision 1.02, 1996, Optical Storage Technology Association

Universal Disk Format® Specification Revision 1.50, 1997, Optical Storage Technology Association

Universal Disk Format® Specification Revision 2.00, 1998, Optical Storage Technology Association

Universal Disk Format® Specification Revision 2.01, 2000, Optical Storage Technology Association

Universal Disk Format® Specification Revision 2.50, 2003, Optical Storage Technology Association

Universal Disk Format® Specification Revision 2.60, 2005, Optical Storage Technology Association

Apple File System Guide, 2018, Apple Inc., available at https://developer.apple.com/documentation/foundation/file_system/about_apple_file_system