

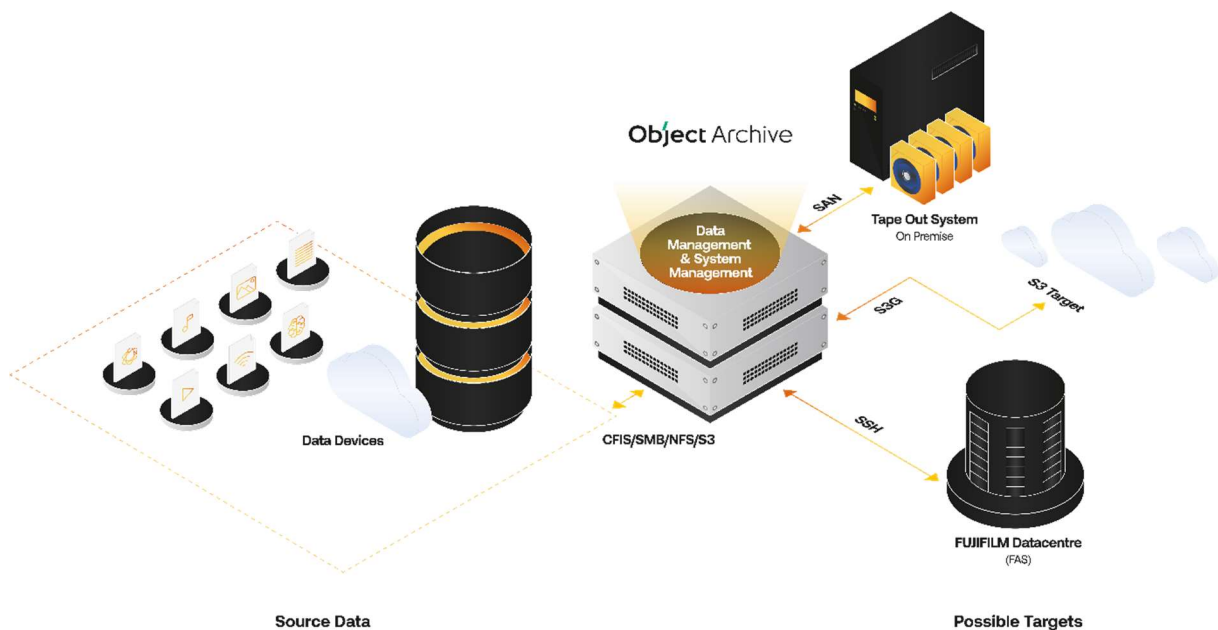
Object Archive

Technical Whitepaper

for

FUJIFILM Object Archive

(Software Revision v.001.60.0)



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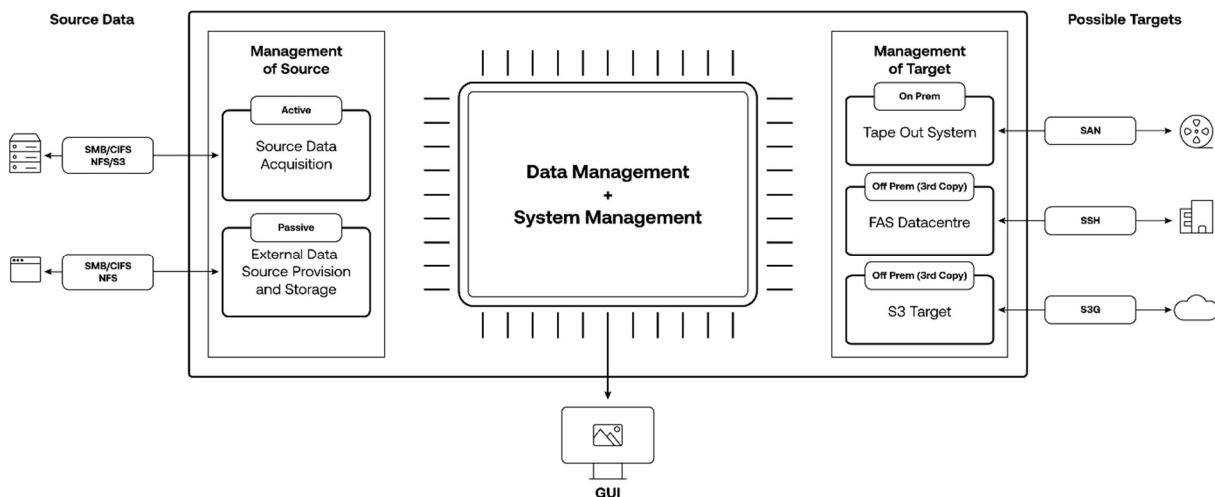
1. Abstract

This document describes the technical features and benefits of the FUJIFILM Object Archive system and provides guidance on designing the system such as hardware selection, configuration, and best practices for effective implementation in a user's existing storage environment.

2. Technology Overview

FUJIFILM Object Archive software is a data management software that can also perform storage system management made specifically for long-term data preservation and data protection. It addresses the increasing needs for a sustainable storage tier for infrequently accessed cold data residing on flash or disk-based storage platforms and reduces overall storage costs. This software can also be used to increase data protection by moving data to tape which can be taken off-line and off-site, for complete, air gapped protection against malware threats or any type of disaster.

Here is an overview of the software architecture:



The FUJIFILM Object Archive software module is designed to run and be compatible with Alma-Linux. As the system will be delivered as a virtual machine or a physical server automatic installation image (also called bare-metal system automatic installation image), the customer must accept the End User License Agreement.

The automatic server installation will not only install the FUJIFILM Object Archive software, but also the underlying operating system. This provides more flexibility in the system software design and an easier installation/setup process. At this point, the user can get started using the system by just answering a few questions interactively. The labour-intensive and error-prone installation process is eliminated.

Technical -Detail:
 Operating System: Alma Linux
 Version: 9.2 Turquoise Kodkod
 Platform ID: el9 / RHEL centos fedora)
 Documentation: <https://wiki.almaLinux.org/>

2.1. Data Source

One of the key features of the FUJIFILM Object Archive programme is the ability to actively fetch data from a source or passively receive data from a sending source.

For this purpose, the software uses a universal network and various transmission protocols.

The default network protocol is Transmission Control Protocol/Internet Protocol (TCP/IP).

2.1.1. Source data acquisition

This active module is one of the first software-modules designed during the creation and development of FUJIFILM Object Archive software, a few years ago.

During this development period, several new protocols were added to widen the communication portfolio for this module.

One of the first protocol connections developed for data information interchange was SMB.

The next protocol for data information interchange was the NFS protocol. This software can connect to NFS service provided with protocol versions of 3, 4, 4.1 and 4.2. The task of this module is to actively take data through one or more of the above protocols from a provisioning service provided by a dedicated hardware.

Network Attached Storage (NAS) is a central file server that allows multiple users to store and share files over a TCP/IP network via Wi-Fi or Ethernet cable. It is also referred to as a NAS box, NAS unit, NAS server, or NAS head. These devices rely on a few components to function, such as hard drives, network protocols, and a lightweight operating system (OS).

The simplest data provisioning service is a server with the appropriate services, whether the OS is Windows, Linux, or Unix.

With the Simple Storage Service, more commonly known as the S3 protocol, the software can also fetch data from systems that do not use any of the standard protocols and are generally referred to as object storage systems. The Source-Data-Acquire module of FUJIFILM Object Archive software acts as another client to the proprietary object storage software and, therefore, there are no additional export costs that some manufacturers require.

FUJIFILM Object Archive Software is the active module that will fetch the data from the customer's system.

2.1.2. External data source provision and storage

The counterpart for the active data acquire module is the passive data receiving module. Originally, FUJIFILM Object Archive software was designed for use as an archiving system in local company and office networks. Since in most cases a central network-compatible storage system was already in use, FUJIFILM Object Archive software was supplemented by another module. As a result, old NAS disk-based systems can now be directly replaced by FUJIFILM Object Archive system. In addition to the costs saved on hardware that was no longer required, this also means that data no longer has to be copied twice over the local network and can be archived directly from the storage medium.

In addition, applications that can communicate directly with storage-enabled network protocols such as the S3 protocol can now also store and modify data without any detours. This is possible with the seamless implementation of the FUJIFILM Object Archive software.

This feature can be enabled separately and requires internal hard drive storage. In the FUJIFILM Object Archive Admin system GUI, different authorization levels can be configured and issued, subdirectories can be created and set individually for each data transfer protocol. Several connections can be used simultaneously, independently of each other.

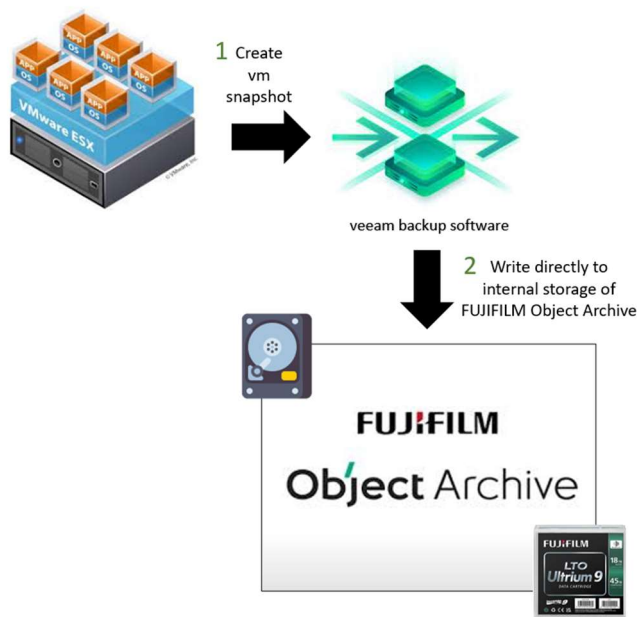
The internal memory of the FUJIFILM Object Archive System also offers the option of serving as a target storage medium for the eventual restoring of data. Applications and other network-enabled programmes and operating systems can then access the data from there.

In the FUJIFILM Object Archive Admin GUI, the status and utilisation of the internal storage system can be called up graphically at any time under the *System information* directory tree entry.

As a note to all users who are looking for a bridging technology for their existing non-tape mass storage system, these systems can also use the internal memory of the FUJIFILM Object Archive system and archive their data on tape in connection with the tape storage module. However, it should be noted that any additional proprietary software creates an additional shell around the data that needs to be archived.

This goes against the actual idea of an archive system, but in exceptional cases it can be necessary and, in fact, useful for certain systems.

Here is an example of a system design:



2.2. Target Endpoints

Any connection that uses the FUJIFILM Object Archive software to send data to one of the three available storage endpoints can do so completely independently of any previously configured endpoints. This means that data from the source drives can be sent to any target drive. These processes can be sequential or parallel.

Data can therefore be sent simultaneously to a tape storage endpoint, to FUJIFILM Archive Services (FAS), which is Fujifilm's high-security long-term archive data centre located in Germany and to any S3 cloud services.

2.2.1. Tape-Out System

This is the tape storage part of the FUJIFILM Object Archive system. Within this system, a user can store mission critical or valuable data on their own premises. The user is able to recall as much as they choose with the highest possible speed.

2.2.2. FAS Datacentre

The FUJIFILM Object Archive system can also send data to FUJIFILM Archive Services (FAS) -Fujifilm's high-security data centre for long-term data archiving. This service can be used as an addition to hosting data in a cloud or in your own system. The FAS service includes data storage in the data centre, as well as creating a third copy and storing that data in a high-security bunker located 35 km away from the data centre. Cyclical, bi-annual checks of the entire data set allow us to guarantee the return of the data in an unchanged form.

The FAS service is available for a fee, depending on the contract period and data capacity.

2.2.3. Cloud Target

Originally conceived as a storage target for tape-based object storage systems, the storage module can address all object storage systems that can be reached internally or externally via a network address. With the corresponding access data, the system can manage a specified object bucket. Since both S3 standard protocol, as well as Glacier protocol are implemented, the data that was moved to another storage subgroup can still be administered.

A further function is a second, redundant object bucket can be addressed by the storage module and is located in a different region. When storing data, two identical but independent copies are always created. With the correct physical separation of the regions on the side of the object storage service provider, a geo-replicant and high-security backup can be created.

2.3. Server System

During the development of FUJIFILM Object Archive software, three principal points were taken into consideration. The ability to read data after decades, to protect archival data with secure accessibility over the long-term, and to provide a cost-effective archiving system.

With this in mind, FUJIFILM Object Archive software was designed to be compatible with all conventional hardware. An open-source system was chosen as the underlying operating system and finally the system interacts with the LTO standard for tape-based long-term archive media.

We recommend the following hardware components as a minimum for the performance operation:

Server System FUJIFILM Object Archive Software
 (Bare Metal System (SType) for productive Systems)
 CPU : 1xAMD EPYC 9124 16C 200W 3.0GHz Processor
 RAM : 8x16GB DDR5 4800MHz (1Rx8) RDIMM-A
 OS-SSD : 2x 2.5" 1.6TB Mixed Use NVMe PCIe 4.0 x4 HS SSD / RAID 1
 Ethernet (NIC): 1x Broadcom 57414 10/25GbE SFP28 2-Port OCP Ethernet Adapter
 FC Card (SIC): 1x QLogic 16Gb Enhanced Gen5 FC Dual-port HBA
 PSU : 2 1100W 230V/115V Platinum Power Supply

2.4. Web Application

The network programmes are designed to ensure simple and complete interaction with the system for all users. It was developed as a platform independent service for use with different web browsers to ensure the best possible compatibility. The system has been tested with Mozilla Firefox and Google Chrome.

2.4.1. Admin GUI

The administrator interface was developed according to the principal: "Keep it simple". All system relevant settings can be operated within this GUI. This includes both the basic configuration settings and the functional operational settings. These options can be easily understood and applied by technical IT personnel at the training level of a system administrator.

2.4.2. User GUI

The second interface is developed for simple, day-to-day use by users. The reduced command set can be used to make the operationally relevant, functional operational settings. This interface is designed more for graphical clarity and comprehensibility for users with the training level of IT user.

Please refer to the Operation Handbook of the FUJIFILM Object Archive User GUI for detailed information.

2.5. Data Management

In addition to controlling the storage systems, FUJIFILM Object Archive software also provides the necessary management tools for operational structuring, cataloguing and retrieval of data and information from the archive storage system.

This sets the FUJIFILM Object Archive system functionally and operationally apart from a pure storage solution and allows a user to manage their data without the need for another cost intensive and complicated additional application.

Supported with numerous ready-made search options, a user can immediately find their data and request it from the archive system without time loss due to interface handling, for example.

2.6. System Management

FUJIFILM Object Archive system is able to interact with different memory endpoints. This includes the storage endpoint of a tape storage system. Enhanced with numerous modules for automatic control, storage and monitoring of data, the Archive Module thus represents the interface between the user and its existing storage systems to FUJIFILM Object Archive system, the highly secure long-term data storage developed by Fujifilm. These modules support users to accurately configure the HW infrastructure needed for the FUJIFILM Object Archive system.

3. Tape Storage

3.1. Open Format- Tape Format

The most important requirement when storing data for archiving is the ability to read the data even after decades. This data (metadata, files, objects, etc.) must not have been changed or modified, and the entire storage is managed as cost-effectively as possible. Below, are the three points that make a good archiving system.



To achieve these three points, there were many hurdles to overcome, both in the understanding of manufacturers and users of memory-based solutions and in the lack of implementation of real archiving methods within software solutions.

One of the central functions of an archive system is the ability to ensure that information stored on separate, external storage mediums are accessible for a long period of time without any data loss, and performant even without an installed and activated archive system. Therefore, it is essential that no disproportionately complex programmes or procedures are required for data retrieval. This means that a simple, cost-free basic operating system without additional software packages must be able to read and process the data from an external data carrier using the appropriate drive hardware.

This ensures that the customer can process their data at any time, regardless of the manufacturer. The customer is thus once again the master of their own data. This is called NO VENDOR-LOCK and, of course, must be standard for a proper archiving system.

Manufacturers should not bind customers to use special hardware or devices. An archiving system should always use standardised and commercially available hardware, such as LTO tape storage media and the compatible drives.

3.2. Different Tape Tasks

a.) Storage Tape

These are the actual storage locations for the archive data. Each tape can manage its own data content and is available to use. No files will be distributed across multiple tapes, except when a file that need to be archived is larger than the capacity of one tape cartridge. The files are organised on the tape in blocks of approximately 16GiB each and are created in TAR format with POSIX encoding. Each block always receives the TAR format header and the footer information.

To manually read the data from a tape without using FUJIFILM Object Archive software, it is possible to readout one block after the other directly from tape. It is not necessary to copy the block into an image file and then partially or completely unpack it with the TAR command. If the user is searching for a file, the user can jump to the corresponding data block and readout the TAR container partially or completely. This structure also allows files extractions to be continued even if there is a broken container in the logical block chain within one connection. For each transfer of data within a connection, the system always creates a group of data blocks on the corresponding tape. Again, the subsequent group of data blocks has a TAR format structure with header and footer information in each block.

To avoid dependencies, no files may be partially stored between different physical data blocks. In the event of damage to one of the blocks, both may no longer be readable. To increase security, and for easier processing, no files are distributed between different data blocks.

Performance can be increased by changing the configuration settings. However, care should be taken that the logical blocks should not be larger than the 16GiB as mentioned above. Files larger than 16GiB are then included as a single data block and thus also as a single file in a TAR container.

b.) System Tape

Every 24 hours, the system automatically creates a backup of all configuration files and the database and saves it on System Tapes. Together with a copy of the Storage Tapes, the system can then be restored in a short timeframe in the event of loss or damage.

This is done by loading a new, empty system with the data from the System Tapes and then activating it. After the inventory check of the Storage Tapes, the system can then be used again.

Without these System Tapes, a new configuration would take considerably more time. All the Storage Tapes must be read by the system and entered back into the database, which can take hours or days depending on the number of tapes.

c.) Transport Tape

In the past it was a part of the nature of tape storage systems that users were not aware of which storage medium their data was located on. This was to allow the storage system to scale independently from memory usage or technology.

However, this is contrary to the outstanding advantage of a tape cartridge being transportable, which is obviously conflicting to the use of a traditional storage memory system. With this function developed by FUJIFILM Object Archive software, the best of both worlds can be combined. The user is given the possibility to store one or multiple data on a tape and to read this tape using the same or another FUJIFILM Object Archive System. The format of the Transport Tape differs from the format of a Storage Tape in that additional information is written to the tape with the user data. This makes it possible for a second FUJIFILM Object Archive system to read a Transport Tape and use it directly, without migration or conversion.

3.3. Self-Describing Format

Definition:

A format that contains data as well as metadata, index data and descriptions that describe the format and meaning (the syntax and semantics of this data) is called a self-explanatory format.

Technical-Detail:

<https://ntrs.nasa.gov/api/citations/20120008476/downloads/20120008476.pdf>

When a user inserts a Storage Tape created by the FUJIFILM Object Archive system in a corresponding to tape drive version and enters the command printed on the cartridge shell, the first file they will see is a detailed description of the type of tape storage medium that is in use, how the data on tape is organized, how and which metadata is stored on tape and which commands are required to acquire all data from this tape or to download all or part of it.

3.4. Self-Healing Architecture

FUJIFILM Object Archive's self-healing architecture provides the possibility of error correction and back-calculation of data based on cross-summation calculation and storage of this information as a header or footer in a digital data container. This data container is executed as a TAR container in the software and has a POSIX encoding.

This procedure is comparable with the parity information of a RAID installation, whereby missing data blocks from computations of readable blocks and checksum blocks can help recover the missing information. However, a calculation of missing information will only be successful up to a certain extent and is always a costly, time-consuming and hardware intensive exercise. If too much data from a file is damaged or lost, these unfortunately cannot be reproduced by the above-mentioned method.

3.5. FUJIFILM Object Archive's Tape Health Check

Each LTO tape cartridge contains a contactless transponder memory chip in addition to the actual magnetic tape storage. All actions that occur while the tape is in a drive are recorded on this chip. All read and write parameters are recorded in detail, how much data was written to or read from the tape and, above all, during which actions there was even the slightest deviation from the standard parameters.

These values are recorded and stored by FUJIFILM Object Archive software after each use of Fujifilm branded tape in the drive. This enables problems and trends to be detected much earlier than with any other software that cannot decode and interpret these values.

This allows the tapes to be tested much more accurately during the cyclic review period. A prediction of the tape life and possible countermeasures can be planned more adequately compared, for example, to when a backup software may indicate, at some point, that the tape is no longer readable.

A small traffic light is simply displayed for each separate tape in the Administrator interface of FUJIFILM Object Archive software. The colours have the simple meanings:



Red: Action immediately required, otherwise a bigger problem is imminent.

Yellow: The system has discovered a possible problem and will keep an eye on it.

Green: Everything in good order shape

There is a chapter in the FUJIFILM Object Archive Manual which describes all possible actions.

This functionality is only available with Fujifilm branded LTO tapes.