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Original Article

Digital preservation: Concepts and strategies

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ABSTRACT

Purpose – The purpose of this study was to identify the digital preservation strategies taken by the members i.e.digital libraries of International Internet Preservation Consortium (IIPC) applying an analytical and descriptive survey. **Design/methodology/approach –** From a methodological point of view, an analytical and descriptive survey was applied in order to form a clear image of the current state of digital preservation strategies as adopted by International Internet Preservation Consortium members (i. e. digital Libraries) so that each member receive a questionnaire relating to this survey via the internet; the compiled information was analyzed using SPSS software and based on the findings, a specimen model was proposed to Iran's libraries. **Findings –** According to our findings, 90.91% of digital libraries apply back-up supply, refreshment, migration of information, and permanent identifiers strategies. In addition to these strategies, 90.91% of the national libraries provide back-ups on daily basis and keep preservation back-up copies on mass storage tools i. e. SAN/NAS and the access back-up copies on portable storage media such as tape library. 100% of the community being studied apply the method of firewalls and virus protection and also they use updated antiviruses against the penetration of viruses into their digital library system. 100% apply the verification mechanism and management of access control, and 10% apply the information verification mechanism to implement the mechanism to control users' access to digital resources of their libraries. **Originality/value –** Due to the novelty of the subject in Iran namely the digital preservation strategies and the emphasis on the application of back-up supply on a daily basis, refreshment of media, and migration of information as preservation strategies, this survey is breaking new ground and appears to enjoy a considerable advantage over its peers.

Keywords: Digital preservation, strategies, digital libraries, back-up supply, access control, migration.

Introduction

From the very outset when the digital collections for libraries began to develop, the issue of their preservation and maintenance has been an inseparable part of the whole thing. As the bulk of digital resources increases, new information in a variety of scientific areas will be incorporated into fragile, unstable, and viable media more and more. The loss of these library resources will have irreparable and detrimental effects on posterity's intellectual perception. Therefore due to the significance of this issue, IIPC (International Internet Preservation Consortium), which is composed of the world's considerable digital libraries, formed in order to support the preservation of digital resources. The goals pursued by this international consortium, include: to perform group works within the legal framework of each country for identification, develop and facilitate the application of some solutions for selection, collection building, preservation and facilitation of access to internet information sources, and global support of initiatives, which would promote collection building and preservation and permanent access to digital resources.

The supporters of storage have discussed the relative advantage of the change of system, emulation, and encapsulation of information for years, and today they have come to the conclusion that different information call for different strategies for the preservation of information resources, which in turn

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depend on the frequency of use and also the importance of information maintenance.

A proper understanding of the resources' characteristics and possible threats to the permanent access to them is the chief point, which should be taken into account in order to achieve this purpose. In terms of fragility and loss of quality, digital storage media are vulnerable and there is no precise method of supporting and refreshing hardware and software and new information carriers. So new procedures and strategies should be designed and implemented [1].

The other issue is the supply of stored digital items in the future. The question is how can we be ascertained that we will see and utilize the digital items in five, ten, or fifteen years to come. Today in most libraries and archives for the long-term preservation of digital resources such strategies are adopted as follows: bit-level preservation, information migration, technology emulation, technology preservation, information encapsulation, supply of back-up copies, etc. To this end, some tools are required to guarantee permanent access [2, 3].

Despite significant technical achievements in processing speed and storage capacity, preserving digital material will go beyond accumulating information on a high-capacity disc and retrieving it. The problem is that we should be able to make the stored information accessible rather than making this digital information just presentable and furthermore, we should be able to keep them alive and accessible for the next generations and at the same time maintain the coherence and homogeneity of information, as well as the intellectual property rights and copyrights of their owners. Since 2000, many national digital libraries around the world, including the USA Congress have taken the initiative to establish an appropriable infrastructure with a view to managing and preserving their valuable works in digital format. The library of American congress within the framework of NDIIPP (The National Information Infrastructure and Preservation Program) the National Library of Australia within the framework of ICABS's third clause concerning the collection and preservation of digital resources, and Netherland's National Library by means of DIAS (Digital Information Archival System) and other digital libraries through other various programs and projects have dealt with the preservation of their valuable digitized resources.

Similarly in Iran since 2001 some initiatives have been adopted by the NLAI to digitize the library resources and the development of a digital library has been officially proposed. To begin, a working group of expert librarians and computer engineers embarked on a survey and review of research projects carried out throughout the world on the digital library. This was done within a research project entitled "Digital National Memory" (HAMD) in research assistance, technology, and programming. Later in 2008, the very project with a few changes under the title "digital national library" was put into operation. The project was intended to digitize all valuable and exclusive resources and to make them available to the public. Lots of old resources including manuscripts, publications of the Qajar period, and old documents were scanned, digitized, and organized in a software named "Nama". Along with the increase of these digitized resources, some arrangements were to be made for the long-term preservation and permanent access to them. This research seeks to put forward a practical and suitable paradigm for the preservation of the digital resources presently existing in the NLAI, once it has surveyed the methods and strategies of digital preservation and the control access and information security in digital libraries, which are members of IIPC.

Digital preservation strategy

The preservation strategy involves the procedure of adopting preservation initiatives in order to preserve a set of digital objects. Thus, a preservation strategy includes preservation initiatives for the applied software and hardware, input and output formats, and preservation strategy various tools, devices, and settings can be defined for various formats [4]. Preservation strategy refers to methods and procedures adopted in most national libraries for the permanent and constant accessibility of the stored digital material in digital repositories.

By considering different aspects like cost-efficiency, legal restrictions, and access requirements of users, the most appropriate preservation strategy should be determined. The preservation strategy based on XML (Extensible Markup Language) is suitable for the exchange of information between two computers and also the transfer of the preserved digital information [5]. The conventional procedures and strategies of digital preservation chiefly include: technology preservation, technology emulation, information migration, information encapsulation, back-up supply, use of identifiers, and digital archaeology. [6-8].

The technology of preservation strategy is a means of overcoming technological obsolescence by preserving software and hardware applied to access a digital resource.

Technology emulation is also a means of overcoming the technological obsolescence of hardware and software by developing procedures to emulate the obsolete systems on the future generation of computers. [9-11]

Migration of information is defined to be the transfer of digital information, while intending to preserve it, within the OAIS. This transfer of information, under full control by the archive, is intended to preserve the full information content and the result is intended to be an adequate replacement of the previous form. Fig 1, extracted from the OAIS Reference Model, provides key functional and information modeling concepts as they relate to migration perspectives. It is done by relating an externally visible identifier for content information to an internal 'AIP Identifier' using local 'Descriptive Storage Mapping'. The AIP is expressed as Packaging Information that contains Content Information and its associated Preservation Description Information.

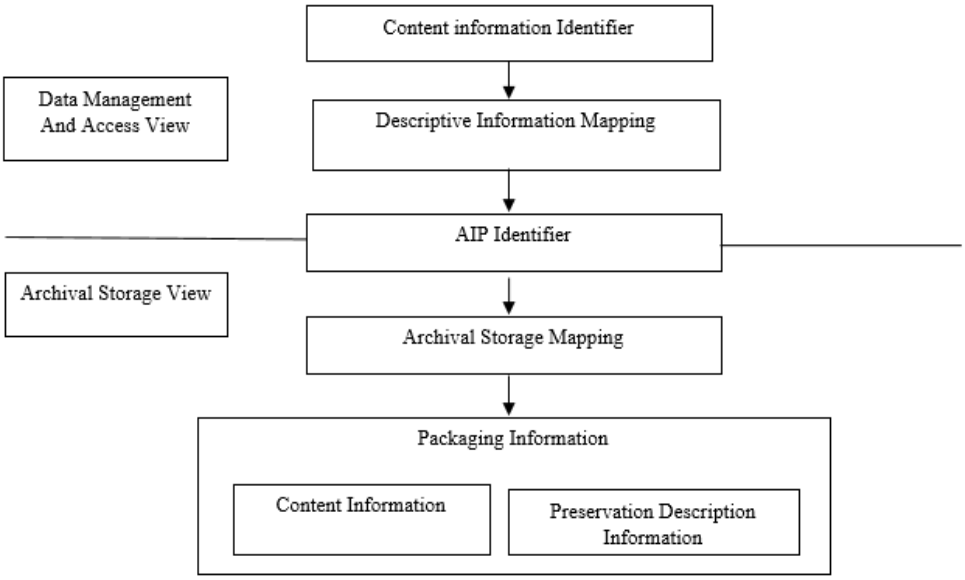

Figure 1. Conceptual view of relationships among key OAIS information concepts, functional areas, and supporting infrastructure

Information encapsulation is to bring together a digital resource or anything necessary to ensure access to the resource in question; by this strategy, the information required to preserve a document is classified. By means of permanent identifiers, we can locate a digital object even when it has been shifted to some other places. And finally, digital archaeology involves the rescue of digital resources, which have become inaccessible owing to technological obsolescence or deterioration of media [9].

This paper deals with a survey of the current state of digital preservation strategy in digital Libraries with the membership of the International Internet Preservation Consortium with a view to identifying digital preservation strategies and maintenance methods and information migration to long-termed storage tools and the analytical, descriptive survey and in conclusion, it is intended to present an appropriate specimen model for digital preservation strategy in digital libraries of Iran.

Crucial Questions

1. What is the most appropriate strategy for digital archiving and long-term storage of digital resources in digital libraries of Iran?
2. Which methods do you apply for the migration and preservation of information in storage tools?
3. As regards permanent access, which methods and procedures are applied by the digital libraries in question?
4. Which specimen model is suitable for the digital preservation strategy in digital libraries of Iran?

Benefits of this research:

- To reduce the expenses of long-termed digital preservation of resources at the digital libraries of Iran.
- To propose an appropriate paradigm of digital preservation for the digital libraries of Iran.
- To help promote the potentialities of digital preservation at the digital libraries of Iran.
- To provide strategies and alternatives for digital preservation in the digital libraries of Iran.

History/Background of the research

The preservation of written heritage, regardless of its format, is of paramount importance to all communities. Digital objects are prone to obsolescence, for they have been recorded with preservation strategies in a particular format on temporary and short-lived media and therefore require an encoding paradigm for use. So, it would be more reasonable to preserve all digital data permanently on standard and durable media by choosing an appropriate digital preservation strategy. The development of a policy for the adoption of an appropriate preservation strategy and preservation programs of digital resources is a distressing challenge for many libraries.

Since the subject "Digital preservation strategies" is new and unfamiliar, no research has been carried out on it in Iran, but much research has been done on the various subjects by libraries, archives, and international organizations abroad of which are briefly described here.

Titia Vander Werf-Davelaar (1999) in his article entitled "Long-term preservation of electronic publications "looks into the NEDLIB research project and the technicalities of digital preservation strategies [12]. The main purpose of this project was to give us insight into the advantages and disadvantages of different strategies adopted for long-term preservation and to

define authenticity in digital preservation. This project has taken the very first step to assess the technicalities of preservation strategies by means of an experiment of technology emulation. Results of this experiment show assuming that appropriate emulators for obsolete platforms can host the future platforms, emulation can act as the foundation in this process [12].

In a report of the CEDARS research project (2002), the project along with the issues regarding preservation and methods of access to resources as well as digital preservation strategies have been analyzed. CEDARS is at the moment implementing pilot projects to assess and promote a selected strategy for digital preservation. The working group of CEDARS's data of preservation strategies attends to those preservation issues relating to migration, emulation, and refreshment. [13].

Svein Arne Solbakk (2003) in his research article entitled "Critical technological and architectural choices for access and preservation in a digital library environment" describe some basic architectural choices for access to and preservation of digital objects at the National Library of Norway [14]. A digital repository is a core element for the handling of both access to and preservation of digital objects. Strategies for giving access to the complete holdings include the use of a powerful search engine and the OAI protocol to harvest metadata from conventional catalogue systems to make textual or structured indexes. [14]

Reinhard Altenhoner (2006) in his article entitled "Data for the future, the German project, co-operative development of a long-term digital information archive (Kopal)" looks into Kopal research project and the long-term accessibility of digital documents, long-term preservation methods and strategies will be discussed in the paper [15]. One of the unresolved problems of the global information society is ensuring the long-term accessibility of digital documents. The project Kopal tackles this problem. The Kopal system will be implemented in accordance with the Open Archival Information System (OAIS) framework. The project will present a stable and reusable platform for additional partners and users, especially for cultural heritage [15].

Sarah Higgins (2007) in her article entitled "Draft DCC Curation Lifecycle Model" describes that a lifecycle approach to the management of digital materials enables visualization of the processes, activities, and relationships required for successful curation and long-term preservation [16]. The model can be used to plan curation and preservation activities within an organization.

Most of the researches in the area of digital preservation strategies in the libraries were carried out after digital libraries had been established and the challenges of digital resources preservation had arisen. Since 1990 when the concept of the digital library was for the first time brought up in the world and many of the Libraries began to digitize their resources, the preservation strategies and maintenance of digital resources have been an inseparable part of the development of the digital collections for libraries. While making policies concerning long-term digital preservation strategies, many aspects such as cost-efficiency, legal restrictions, and users' access requirements should necessarily be taken into consideration. With regard to a variety of digital preservation strategies in the survey of research projects, it was observed that in most of these projects, back-up supply, refreshment of media, migration to new media and technology emulation have been proposed as appropriate strategies for the preservation of digital resources.

Analysis of Data

There are various methods adopted to store digital material, which include:

- storing what is received in mass storage
- migrating to some other storage tools
- providing back-ups on storage media
- keeping records in a safe place far from SAN
- providing several back-ups and keeping them in a safe place

Digital resources could be stored on any storage medium (e.g. CDs & DVDs) to show bits and binary figures. The tables below show and analyze these methods.

Table 1. Methods of long-termed storage

Type library	Storing what is received in mass storage	Migrating to some other storage tools	Providing backups on storage media	Keeping records in a safe place far from SAN	Providing several backups and keeping them in a safe place
Italy	1	0	0	1	1
Australia	1	1	1	1	1
Iceland	1	0	1	0	1
The British Library	1	0	1	1	1
Denmark	1	0	0	0	0
Sweden	1	1	1	1	1
France	1	0	1	1	1

Canada	1	0	1	1	1
Norway	1	0	0	0	0
Finland	1	0	1	1	1
United state	1	0	1	1	1
total	11	2	8	8	9
percent	100	18.18	72.73	72.73	81.82

100% of the libraries employ this method i.e. storing what is received in mass storage tools. 81.82% make several back-up copies and keep them in a safe place. 72.73% provide backups on storage media and maintain digital objects in a safe place and far from mass storage technology (SAN/NAS). And 18.18% draw on the migration of the received resources to other storage tools for the digital preservation of their resources.

Table 2. Types of digital preservation strategies

Type library	Technology preservation	Technology Emulation	Information Migration	Encapsulation	Digital Archaeology	Data backup	Persistent Identifiers
Italy	0	1	1	1	0	1	1
Australia	1	0	1	1	1	1	1
Iceland	0	0	0	0	0	1	0
The British Library	0	1	1	1	1	1	1
Denmark	0	0	1	1	0	0	1
Sweden	0	0	1	1	0	1	1
France	1	0	1	1	1	1	1
Canada	1	0	1	1	1	1	1
Norway	0	0	1	1	0	1	1
Finland	0	0	1	1	0	1	1
United state	1	0	1	1	0	1	1
total	4	2	10	9	4	11	10
percent	36.36	18.18	90.91	81.82	36.36	100	90.91

100% of the libraries apply the strategy supplying back-up, 90.91% of the Libraries use information migration strategies and permanent identifiers to locate digital resources and for the long-term preservation of their digital resources. 81.82% employ information encapsulation strategy in the OAIS reference model. 36.36% have attempted to use the strategy of technology preservation and digital archaeology and 18.18% apply technology emulation strategy. This goes to show that approximately most of the International Internet Preservation Consortium members apply back-up supply and information migration & permanent identifiers strategies for the long-term preservation of their digital resources. On the other hand, the strategy of technology preservation and archaeology of digital data are used most infrequently since the technology in question has become obsolete. Emulation strategy has not received much attention, as it has proven to be very costly.

Table 3. The range of users for access to resources

Type library	public	particular group of their users	library members	library staff	the users by enforcing the copyright law
Italy	1	0	0	0	0
Australia	1	1	0	1	0
Iceland	1	0	0		0
The British Library	1	0	0	0	0
Denmark	1	1	0	0	0
Sweden	0	1	0	0	0
France	1	1	1	0	0
Canada	1	1	0	0	0
Norway	0	0	0	0	1
Finland	1	1	0	0	0
United state	1	1	0	0	0
Total	9	7	1	1	1
Percent	81.82	63.64	9.09	9.09	9.09

The findings show that 81.82% of the community in question are rendering services to the public. 63.64% enable a particular group of their users to access the collection of their library digital resources. The Digital library of France (9.09%) renders services to the library members, the library of Australia (9.09%) to the library staff, and the library of Norway (%9.09) to the users by enforcing the copyright law.

Table 4. Methods of accessing digital resources

Type library	free access to the entire collection	access by restricting copyright	access to the library digital resources chargeable to users	free access to a part of the collection of digital resources	delivering them in the form of CD_ROM and DVD	visit the digital archive of the library and authorize them to access the resources.
Italy	0	1	1	1	0	0
Australia	1	1	0	0	0	0
Iceland	1	0	0	0	0	0
The British Library	0	1	1	1	1	0
Denmark	0	1	0	0	0	0
Sweden	0	1	0	1	1	0
France	0	1	0	1	1	1
Canada	0	1	0	0	1	0
Norway	1	0	0	0	0	0
Finland	0	1	1	1	0	0
United state	0	1	0	0	1	1
total	3	9	3	5	5	2
percent	27.27	81.82	27.27	45.45	45.45	18.18

81.82% provide users with the method of access by restricting copyright. 45.45% of the libraries allow for free access to a part of the collection of digital resources and also delivering them in the form of CD-ROM and DVD. 27.27% of the libraries allow for free access to the entire collection and access to the library's digital resources chargeable to users. And 18.18% enable the users to visit the digital archive of the library and authorize them to access the resources.

Table 5. Methods of protecting digital objects against the unauthorized entrance of users

Type library	public	particular group of their users	library members	library staff
Italy	1	1	1	1
Australia	1	1	1	1
Iceland	1	1	0	0
The British Library	1	1	1	1
Denmark	1	1	0	0
Sweden	1	1	1	0
France	1	1	1	1
Canada	1	1	1	1
Norway	1	1	0	0
Finland	1	1	1	0
United state	1	1	1	1
Total	11	11	8	6
Percent	100	100	72.73	54.55

%100 of the community being studied apply the method of firewalls and virus protection and also use updated antiviruses against the penetration of viruses into their digital library system. 72.73% utilize the method of firm authorization of the users to benefit from the digital resources of their library. 54.55% draw on security alarms to guard digital objects against the invasion of viruses and the users' intrusion.

Firewalls and virus protection and the use of updated anti-viruses rank as the most frequent methods of protecting digital objects against the unauthorized entrance of users) and penetration of viruses into libraries.

Table 6. All types of mechanisms of security management

Type library	key management	encoding	digital signature	access control	verification mechanism	control and monitoring routes
Italy	1	1	1	1	1	1
Australia	1	1	1	1	1	1
Iceland	0	0	0	1	1	0
The British Library	1	1	1	1	1	1
Denmark	0	1	0	1	1	0
Sweden	1	1	0	1	1	1
France	1	1	1	1	1	1
Canada	1	1	1	1	1	0
Norway	1	1	0	1	1	0
Finland	1	0	1	1	1	1
United state	1	1	1	1	1	1
total	9	9	7	11	11	7
percent	81.82	81.82	63.64	100	100	63.64

%100 apply verification mechanism and management of access control for the security of the resources information at their digital library system. 81.82% use key management and encoding. 63.64% make use of control mechanisms and monitoring routes and digital signature to guarantee the security of resources information of digital libraries system. None of the digital libraries being studied has drawn on the mechanism of the management of data integrity. Thus, it was excluded from the table.

Table 7. All mechanisms of access control

Type library	databases of access control within a hierarchy	information verification	security tags	the time of users' access	the route of users' access
Italy	1	1	0	1	1
Australia	1	1	1	1	1
Iceland	0	1	0	0	0
The British Library	1	1	1	1	1
Denmark	0	1	0	0	0
Sweden	0	1	0	1	1
France	1	1	1	1	1
Canada	0	1	1	0	0
Norway	0	1	0	0	0
Finland	1	1	0	1	1
United state	1	1	1	1	1
total	6	11	5	7	7
percent	54. 55	100	45. 45	63. 64	63. 64

%100 apply the mechanism of information verification (using passwords, property, etc.) to implement the mechanism of access control of users to the digital resources of their libraries. 63.64% use the mechanism of timing and controlling the route of users' access. 54.55% utilize databases of access control within a hierarchy. 45.45% apply security tags to access control of users to the digital resources of libraries.

Conclusion

Studies carried out in the area of digital preservation and the survey of the status of digital preservation strategies in the Libraries with the membership of IIPC have led the researcher to some findings, which could pave the way for the implementation of appropriate strategies of digital preservation in the digital libraries of Iran. Preservation strategy is the procedure of adopting preservation initiatives to protect the collection of digital objects. The most appropriate preservation strategy should be determined by taking different aspects such as cost-effectiveness, legal restrictions, and access requirements of users into account. The preservation strategy based on XML (Extensible Markup Language) is suitable for the interchange of information between two computers and also the transfer of preserved digital information. The findings of the current research are confined to the two activities: digital archiving and permanent access through access control and security. On the

other hand, the findings of this research helped the researcher present a paradigm for digital preservation at. Broadly speaking, the results of this research include: in most of the Libraries in question, a blend of the strategies "back-up supply", "information migration", and "permanent identifiers" has been adopted to locate and preserve the digital resources of libraries in the long term. Cost-effectiveness and user access requirements to digital resources are considered the most important and frequent factors in the selection and use of an appropriate preservation strategy at libraries. The strategy of migration aims at the maintenance of the intellectual content of digital objects and accessibility for the users to retrieve information. Migration, emulation, refreshment by CEDARS (2002), migration, emulation and permanent identifiers by Solbakk (2003), and technology emulation in CAMiLEON's report have been introduced as digital preservation strategies [14]. Storage of whatever enters the library and a large number of back-ups and their storage in a place far from the tools of mass storage (eg. SAN) rank as methods of long-term preservation at digital libraries of Iran.

Defensive procedures such as firewalls, virus protection, and the use of updated antiviruses against virus invasions have been applied in the system of digital libraries. The mechanism of access control management, verification, key management, and encoding as mechanisms of security management have been employed to implement the security of information within the system of digital national libraries in question. According to the result, 81.82% of the libraries use the method of access with restriction of copyright in order to access the digital resources of their libraries. Therefore, it is proposed to the to apply access with restricted copyright for high-quality copies and to apply free access at the site for low-quality access. %100 of the community being studied, employ firewalls and virus protection and verification mechanism and access control management for the security of resources' information within the system of their digital library.

Proposed paradigm

The relevant findings were reflected in table 1 and showed that 90.91% apply the strategies "back-up supply, migration and permanent identifiers to locate digital resources and preserve them in the long run. Moreover, there are various methods for maintaining digital material. According to one of these methods, whatever enters the library is maintained in the technology of mass storage. Digital resources can be stored on any portable media (e.g. CDs, DVDs, and tape library) to show binary figures and bits. The first step to guarantee the preservation of bit streams is to copy and store the bit stream on a stable medium or in other words to refresh it, for this case, if the digital medium perishes or becomes obsolete, the digital data will get lost unless they have already been copied on a new medium. In the process of refreshing, back-ups will be reproduced containing the whole digital information. Usually, a huge quantity of back-ups from digital information is provided at libraries and these back-ups are maintained in a safe place far from mass-storage tools. In this paper (according to Table 2), it should be asserted that back-up supply on a large scale and their maintenance in a safe place far from SAN for the digital libraries of Iran is suggested. The method of maintenance and mass storage of all resources, which enter digital libraries according to deposit law is studied in most of the libraries.

Therefore in the access section, it is suggested to the digital libraries of Iran to/that:

- apply access with restricted copyright for high-quality copies and free access to the site for low-quality copies.
- the users be classified in order to access the resources within the software (AZARSA) that is to say, specific users who are researchers and use digital resources for research purposes, general users including a wide range of people, and member users who are provided with a password and intelligent membership cards.
- develop proper software and hardware infrastructure for the information security within the system of the digital library at the digital libraries of Iran.
- preservation and security systems at digital libraries should protect the digital objects against unauthorized changes whether intentional or unintentional. In such systems, defensive procedures such as firewalls in the Ingest, archival storage, verification mechanism, and access control management should be utilized.

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