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Digital preservation practices for Institutional Repositories (IRs) of Universities in Kenya.

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I. Introduction

Academic libraries play an important role of imparting knowledge to the communities they serve in institutions of higher learning. However due information explosion, libraries have found themselves in precarious position to store all the information content being produced. This has led the information managers to be creative in solving space problem. The emergence of institutional repositories (IRs) gave academic libraries a sigh of relief to share and preserve digitized content to the scholarly community. Issues of long term preservation of IRs have always affected their development and maintenance. If the question of long term preservation is not well addressed it will erode credibility and goals of IRs. Durant, (2010) defines digital preservation as "the whole of the principles, policies, rules and strategies aimed at prolonging the existence of a digital object by maintaining it in a condition suitable for use, either in its original format or in a more persistent format, while protecting the object's identity and integrity, that is, its authenticity."Scholars like Kirchhoff, (2008) support this holistic definition by describing digital preservation as "the series of management policies and activities necessary to ensure the enduring usability, authenticity, discoverability and accessibility of content over the very long term." The two definitions agree that digital preservation is holistic and takes into consideration management (rules and policies among others) as well as actions/activities necessary to ensure the resources have integrity and are available and usable in future. Preservation and access go hand in hand. It is impossible to promote access without preservation. IRs have to take digital preservation seriously to ensure that their goals to both institutions and users are fulfilled.

Digital Preservation Strategies

Shimray & Ramaiah, (2018) defines a digital preservation strategy as a deliberate documentation method for the preservation of digital content as well as a broad approach adopted by an organisation to ensure that the content of digital records remains in a usable form over time. According to Verheul (2006) there is no single strategy that can achieve long-term preservation and access to all the types of digital resources stored in digital repositories. Bountouri (2017) proposes that strategies should be based on proactive preservation indicating that these strategies should be applicable throughout the life of the digital object. According to Barrueco and Termens, (2021) digital preservation strategies should start at the creation of the digital objects by raising awareness among the creators. UNESCO's Guidelines for the Preservation of Digital Heritage (2003) group digital preservation strategies into four groups:

Short-term Strategies

These are digital preservation strategies that are geared towards providing access to digital resources for a predetermined period of time. They include:

Bitstream Copying: This is the process of making an exact duplicate of a digital object (D.P. **Workshop:** Digital preservation strategies, 2014). It works in combination of other digital preservation strategies like remote storage, refreshing and migration. It only addresses the problem of data loss either through malicious destruction, normal decay or natural disaster. It is also intended to maintain authenticity and integrity (Arora, 2009).

Refreshing: refers to copying of digital information from one long-term storage medium to another of the same type, with no change whatsoever in the bit stream (e.g. from a decaying 4mm DAT tape to a new 4mm DAT tape, or from an older CD-RW to a new CD-RW). Refreshing is a necessary component of any successful digital preservation program, but is not itself a complete program. It potentially addresses both decay and obsolescence issues related to only the storage media.

Technology Preservation: this strategy involves preserving the computing environment and it is sometimes called the "computer museum" solution. It has been argued that technology preservation is more of a disaster recovery

strategy for use on digital objects that have not been subject to a proper digital preservation strategy (Arora, 2009; Ismail & Affandy, 2018). Others have argued that the strategy offers the potential of coping with media obsolescence, assuming the media hasn't decayed beyond readability (Arora, 2006; Digital preservation Management, 2009; Harvey, 2011).

Normalization: CLIR & LoC (2002) describe normalization as the aspect of collecting various file formats and conversion them to one file format. In essence it is a formalized implementation of reliance on standards. It involves gathering all the digital objects of a particular type (for example color images, structured text) within a repository and converting them into a single chosen file format that is thought to embody the best overall compromise amongst characteristics such as functionality, longevity, and preservability (Arora, 2009).

Encapsulation: encapsulation has been described as "a technique of grouping together a digital object and metadata necessary to provide access to that object" (Beagrie, 2002, p.108). Ostensibly, the grouping process lessens the likelihood that any critical component necessary to decode and render a digital object will be lost. Appropriate types of metadata to encapsulate with a digital object include reference, representation, provenance, fixity and context information (Deshpande, 2016). According to Harvey (2005), encapsulation is a prerequisite to emulation.

Universal Virtual Computer (UVC): Lorie (2001) describes a UVC as a Computer in its functionality, Virtual as it will never have to be built physically and Universal because its definition is so basic that it will endure forever suggesting that all that was needed was to write a UVC interpreter that could be written for any machine without changing the UVC program that is independent of architecture. According to Mohanty and Das (2014) a UVC requires the development of a computer program that is hardware and software independent and has the ability to simulate the basic computing environment architecture of every computer since the beginning. It uses both the elements of migration and emulation

Analog Backups: This strategy combines the conversion of digital objects into analog form with the use of durable analog media. Hoke (2012) give an example of converting digital to paper arguing that paper offered a longer lifespan but at the same time warned that the repository risked losing some digital qualities such as accessibility, lossless transferability and increase in costs especially storage if volume increases a feeling supported by Harvey (2005) who termed it as a non-solution.

Challenges to Digital Preservation

Libraries, archives and museums today face numerous challenges among them technology obsolescence, information overload as well as maintaining trust as repositories that hold documentary evidence of scholars and citizens (The Council of Canadian Academies, 2015). In addition, digital records are inherently software-dependent posing immense challenges to its long-term preservation (Dar & Ahmad, 2017; Matlala, 2019). Rendering the bit stream of a digital object into an understandable and useable information object requires software and hardware designed to interpret the bit stream in accordance with an underlying file format (The community archives and heritage group, 2018). Howell, (2000), notes that digital materials require a specific hardware and software in order to access them without which information in digital format is incomprehensible, useless and irrelevant. Hedstrom and Montgomery (1998), in a survey of 54 institutions found out that technology obsolescence was generally regarded as the greatest technical threat to ensuring continued access to digital material. It is the single most major risk to long term preservation of digital information. For example, magnetic tapes with varying storage densities replaced punch cards. Arora (2009) agreed with them by concluding that machine dependency was one of the greatest challenges to digital preservation since computer and storage technologies were in a continuous flux of change, giving little timeframe for organisations to migrate digital contents to new software / hardware and could be within the 3 to 5years, as opposed to decades or even centuries that may be available for preserving traditional materials. The threat to digital content caused by technology obsolescence is summed up by Johnstone (2020) by noting that there are dozens of carrier formats - floppy disks, hard drives, CDs, DVDs, thumb drives, tapes among others requiring hardware that is no longer manufactured or supported by modern personal computer architectures and software that can no longer be found online, even if the original manufacturer still exists. Today, manufacturers are phasing out optical readers and librarians have no other option but to provide alternatives to access information in CD ROMs. Niehof, et al 2018 and Langley (2019) decried the limited time afforded to managers of digital content to save them due to rapid changes in technology and complexities of technologies involved.

Fragility of the media is another major challenges that custodians of digital material wrestle with'. According to Hedstrom and Montgomery, (1998), the media digital materials are stored on is inherently unstable and without suitable storage conditions and management can deteriorate very quickly even though it may not appear to be damaged. Arora (2006) adds on that most storage devices, without suitable storage conditions and proper

Management, deteriorate very quickly wand this may lead to loss of data. Tallman and Work (2018) summed it up by arguing that physical degradation of hard drives and other digital storage media can lead to file corruption.

Rapid changes in technologies render file formats obsolete. This is compounded by the existence of many types of formats making it difficult for repository administrators to keep track of them. Pearson and Webb (2008), described file format obsolescence as a major risk factor threatening the ongoing usefulness of digital information collections. According to Arora (2006), the problem is compounded by the fact that many of the most commonly used computer applications rely on proprietary native file formats to create, save, store, manage and retrieve digital content. According to Duff, et al(2006), digital preservation is an extremely complex, evolving field that requires a great deal of knowledge to understand which when coupled with the high speed of technological changes mean that few organizations are able fully to articulate what their needs are in this area, much less employ or develop staff with appropriate skills. It has also been noted that there is little in the way of appropriate training and "learning by doing" is often the most practical interim measure a point that was brought out clearly by Engelhardt, (2013) in "The DigCurV Review of Training Needs in the Field of Digital Preservation and Curation" done in Germany, Ireland, Italy, Lithuania, and the UK. The study concluded that there was a severe lack of professionals with the skills and competences necessary to deal with digital preservation tasks not only among the existing staff in institutions but also among potential staff in the labour market compounded with the lack of appropriate training options. A recent study by Masenya and Ngulube (2019) in South Africa also identified a lack of training and skills in the industry and went on to recommend use of external expertise and investment in staff training especially through workshops and seminars. This is in agreement with Alison, et al (2019) when they shared the University of Glasgow's Digital Preservation Journey 2017-2019 and found out knowledge and skills among the staff were enhanced by participating in a national digital preservation pilot project and learning from practitioners through workshops and information exchange.

The integrity of digital information resources is critical to their use. According to the Council on Library & Information Resources & the Library of Congress (2002), Information security guarantees trust. Information security encompasses a number of aspect such as: confidentiality, availability, integrity and authentication (Campisi, et al, 2009). In a repository perspective, availability ensures that the information is available and can be used when needed a notion supported by NISO (2007) who described availability as ensuring that the collection is accessible and usable upon demand by an authorized but goes on to clarify that this does not mean that materials should be free and unrestricted for all but attempts should be made to ensure that resources are as widely available as possible within the required constraints. Integrity ensures that it is not corrupted while authenticity ensures that it remains original. Owens (2018) argues that information security goes beyond having backups but also ensuring that any changes done on the digital document is recorded and legitimate.

Intellectual property rights has been described as one of the biggest problems in digital preservation (RLG, 1996). Whitt (2017) opines that unless an information resource is exempted by copyright law; is in the public domain or preservation is done by copyright owner then institutions have challenges because irrespective of the strategy adopted, some form of copying is done leading to infringement of copyright. Kilbride and Norris (2013) warns that there are risks when digital preservation actions are delayed due to IPR issues and recommends adoption of appropriate and practical actions to manage the risks.

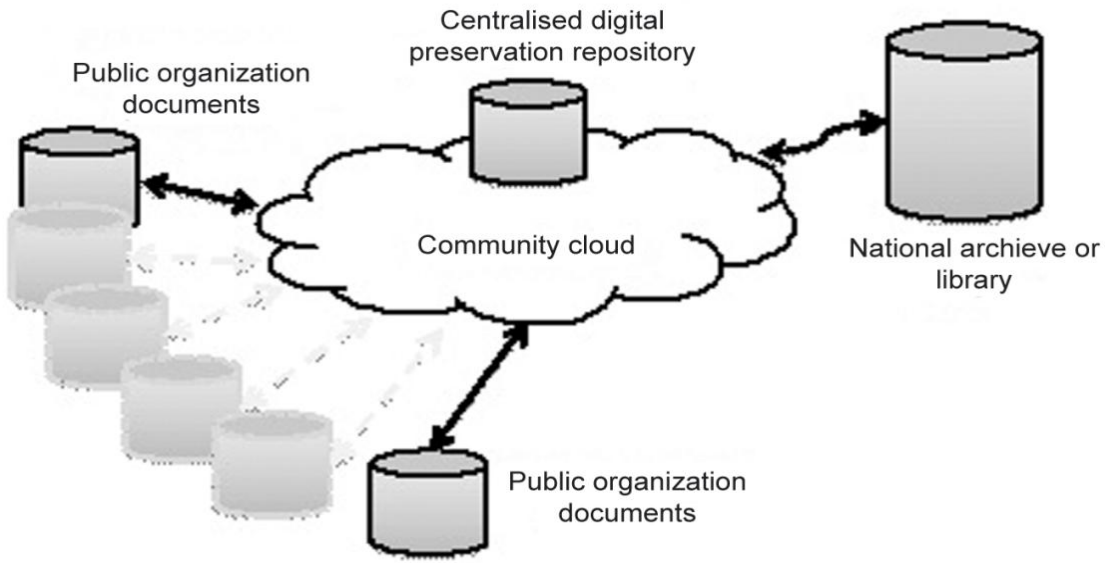
Limited funding has been and continues to be an obstacle to digital preservation forcing organisations to develop policies that can be implemented with limited budget (Owens, 2018). Wittenberg et al (2018) challenged the trend in higher education funding which reflected on limited funds received by the libraries making them focus on content acquisition at the expense of digital preservation activities. This limited funding has resulted in failure by libraries in Nigeria to invest in infrastructure to support digital preservation (Solomon & Soyen, 2021). Weinraub et al (2018) summed it up by declaring that funding remained a major impediment to the establishment of a robust digital preservation program.

Digital objects today are made of various components all presiding in one repository (Wittenberg et al, 2018). This complexity underscores the need to create, capture and maintain more information on context and relationships in order to support discovery, access and rendering in future. Baillieul, Grenier & Setti (2018) notes that versioning which is one of the components of complexity needs authoritative monitoring and proposes infrastructure that supports distributed systems ranging from author personal websites, publisher portals and IRs.

Heterogeneity: Johnstone (2020) argues that no community or organization can to create, collect, and/or preserve just a single type of born-digital or digitized object since there exists many types of file formats as well as a number of variants of the same format.

Digital Preservation Trends

Today organisations implement digital preservation either in a centralized or distributed model. Centralized preservation refers to preservation activities managed by single institution like DAITSS, a digital preservation software application developed by the Florida Center for Library Automation (FCLA) and used by Florida Digital Archive (FDA), a long-term preservation repository service provided by the Florida Virtual Campus for the use of the libraries of the eleven publicly-funded universities in Florida, (FCLA, **2011**). The preservation protocol implemented by DAITSS combines bit-level preservation, format normalization, and forward format migration (Caplan, 2008). Decman and Vintar (2013) proposed a centralized digital preservation solution for e-government based on cloud computing. They suggested a single repository for digital information held by governments institutions and departments instead of each managing their own.



Centralized Digital Preservation Model
Source: Decman and Vintar (2013)

Distributed preservation refers to Preservation activities managed by multiple institutions replicating and/ or geographically locating collections like the Meta-Archive Cooperative. According to Skinner and Halbert (2009), distributed digital preservation involves collaboration between like-minded institutions and is meant to alleviate problems arising from scarcity of resources since a single institution may not maintain infrastructure in different resources to support long-term access to digital resources. Skinner and Halbert (2009) went on to propose that best practice for distributed preservation is to have a minimum of three sites for the resources, that sites preserving the same content should not be within a 75 to 125 miles' radius of one another, sites should be away from paths of natural disasters, should not share power grids, under different administrators and should be on live media frequently checked for bit rot.

The Florida Centre for library automation (2011) argues that no one institution can preserve everything and neither can they be wholly isolated and independent organizations. There has been a National and international focus on mechanisms for cooperation, coordination, and federation of preservation efforts, as well as the development of shared standards. For example, in the United States, the National Digital Information Infrastructure and Preservation Program (NDIIPP) program is taking the lead in establishing a distributed digital preservation network while in Europe, the PLANETS (Preservation and Long-term Access through Networked Services) project funded by the European Union is a major vehicle for integrating distributed preservation services (Baucom, 2019). Proponents of distributed systems Trehub and Halbert (2012) argue that there is safety in numbers and support the adoption of the Lots of Copies keeps Stuff Safe (software).

Evaluation of Digital Preservation Practices

The main objective of a digital preservation program is to be able to assure stakeholders that information held in digital form and is understood today can be transmitted into an unknown system in the future and still be correctly understood (Antunes et al, 2012). To achieve this objective quality management is one of the essential

parts of any digital archive (Dobratz et al, 2010). The idea of establishing the effectiveness of digital preservation practices was born in December 1994 when the Commission on Preservation and Access and the Research Libraries Group created the Task Force on digital archiving with the mandate to investigate the means of ensuring continued access indefinitely into the future of records stored in digital electronic form (Waters & Garrett (eds.) (1996)). The taskforce identified a gap that required for a process of certification for digital archives to cultivate a climate of trust about the prospects of preserving digital information (Waters & Garrett (eds.), (1996). From this evolved the first check list which later became ISO 16363/TDR to evaluate digital preservation environments in digital repositories (Baucom, 2019). According to Maemura, et al (2017) assessments should form a major component of a digital preservation program because it is only after an assessment that a digital repository can demonstrate efficacy as well as bridge any gaps identified and consequently promote trust amongst the stakeholders.

Many digital repositories are today using preservation needs analysis to audit the status of their preservation activities. Durant (2019) describes a preservation needs assessment as a broad, holistic evaluation of how an organization cares for and preserves its collections aimed at describing the impact of the existing conditions and policies on the collections, and providing corresponding short, medium, and long-term steps that an organization can take to benefit the materials under its care. Maemura, et al (2017) notes that evaluations can range from simple check lists to rigorous audits while the categories of assessment used can be both descriptive or qualitative (Durant, 2019). Despites the necessity to carry out assessment, it is faced with some challenges with Antunes et al (2012) decrying the lack objective assessable (measurable) features regarding long-term aspects proposing the use of indicators to show the degree of trustworthiness. Researchers like Pearson and Coufal (2013) proposed some metrics by describing an ideal digital preservation environment as consisting of a mix between policies, processes and resources that comprise staff and technologies.

In the area of institutional repositories, Dell and Shultz (2014) felt that it was important that IRs adopted practices that could be tracked, audited and measured as this encouraged the designated communities to trust them as custodians of their research output. According to Altman et al (2019) much content has been lost due to organizational failure and recommends an audit of content, and the evaluation of organizations themselves to mitigate the risks. Although the preservation community has made considerable progress towards articulating the practices and behaviors of trustworthy preservation, organizations have been slow in conducting reliable evaluation of their digital repositories (Altman, et al, 2019). Maemura, et al (2017) identified three approaches to the evaluation of digital preservation in organisations. These include evaluations aimed at planning, improvement and those aimed at certification. Whatever approach the organisation chose, the evaluation assists the digital repository to document its digital preservation success, report areas that need further growth, and identify challenges that could prevent that growth (Tapscot 2019).

II. Conclusion

Successful digital preservation programs are imperative in IRs to support long term accessibility of the digital resources in their custody. Institutional repositories in Kenya have a commitment to collect, store, preserve and disseminate the resources in their care.In the light of the findings, the study concludes that IRs in Kenya have not incorporated best practices required to support long-term preservation of digital resources. The current state of digital preservation practices indicated visible disparities with industry best practices. as evidenced by lack of preservation policies and plans. This was as evidenced by lack of content selection policies, procedures for content creators, preservation policies and plans as well as staff development strategies to equip them with digital preservation skills.

It is also imperative that comprehensive digital preservation policies are required to create a conducive environment for digital resources in the custody of the IRs.Successful digital preservation should be guided by comprehensive policies outlining the scope and aim, content and formats as well as authority for staff to carry out digital preservation activities. Digital preservation is expensive and as such, the development of selection policies is very critical for its success as it identified digital objects that could be preserved long-term as well as resources that met the need of the designated community. The IRs lacked metadata policies that guided metadata collection and management as well as a technology plan to guide them in digital object management, infrastructural investment and technology watch. Because of a nonexistent policy framework, preservation actions were performed haphazardly with no documented preservation strategies identified contrary to best practices that require that this be the case.

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