PRESERVATION STRATEGIES FOR NEW FORMS OF SCHOLARSHIP

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Abstract – The advance in technologies for publishing digital scholarship has outpaced the development of technologies for reliably preserving it. Authors and publishers are creating increasingly sophisticated products without realizing that some of their enhancement choices might put preservability--and valuable scholarship--at risk. In a project funded by Andrew W. Mellon Foundation and led by NYU Libraries, a group of digital preservation institutions, libraries, and university presses collaborated to study examples of these dynamic forms of scholarship to determine they could be preserved in their current form and whether it would be possible to do this at scale. This paper will provide a summary of this project and key themes that could impact preservation of enhanced scholarly works.

Keywords – scholarly publishing, web archiving, emulation, dynamic content, preservation strategy

Conference Topics – Community; Innovation.

I. INTRODUCTION

Scholars are making extensive use of new digital technologies to express their research. Publishers, in turn, are working to support increasingly complex publications that are not easily represented in print. These enhanced digital products introduce new complexities in content and user experience. Examples include publications with embedded audio and video content, high-resolution images, data, maps, and visualizations; non-linear paths of engagement; and complex interactive features that depend on third party platforms or APIs, such as YouTube or Google Maps. Each of these innovations presents preservation challenges; their combination creates an even greater challenge: the need to maintain multiple formats and the connections among them, all within workflows designed for simpler objects.

To study this challenge, a group of digital preservation institutions, libraries, and university presses worked together on an Andrew W. Mellon Foundation funded project, Enhancing Services to Preserve New Forms of Scholarship, led by New York University Libraries. Preservation service providers, such as Portico and CLOCKSS, rely on economies of scale with replicable processes, and as such, they must determine what aspects of new scholarly communication can be preserved at scale. Authors and publishers, for their part, must provide sufficient contextual information for publications in order for essential features to be preserved. Together, a team of publishers, librarians, and preservation specialists examined a variety of enhanced digital publications in order to identify what can be effectively preserved at scale with existing technologies. This analysis was used to produce a recommended set of practices to help authors and publishers prioritize and plan their enhanced digital products for maximum preservability. A full report [1] on the project and the resulting guidelines [2] for authors, publishers, and publishing platform developers have been published. A summary of the project and reflections on key themes that could impact preservation of enhanced scholarly works are described in this paper.

II. METHODS

Project participants represented scholarly publishers, preservation services organizations, and libraries that may provide publishing services, preservation services, or both. Publishers included NYU Press, Michigan Publishing, the University of Minnesota Press, UBC Press and Stanford University Press. Four out of five of the participating publishers also participated as platform developers: NYU Press

for Open Square, Michigan Publishing for Fulcrum, the University of Minnesota Press for Manifold, and RavenSpace at UBC Press. Preservation service organizations included CLOCKSS, Portico, and the libraries of the University of Michigan and NYU.

The 18-month–long project was divided into three sprints, with publications grouped by their technical features and in order of what was perceived to be the least to most complex. During the first sprint, the team worked with EPUB-based publications that include a variety of multimedia and supplementary material either within the EPUB itself or as a platform-level resource. During the second sprint, the team modeled solutions for preserving web publications with a linear, text-based structure and a broader range of added digital resources. Though these publications are interactive, users engage with them through a predictable set of interactions. Many of the publications in both the first and second sprints support enhanced features such as annotations, embedded multimedia, and data visualizations. The third sprint covered the most complex, media rich, and nonlinear publications for which an interactive experience is at the forefront. In this sprint, the team worked with more dynamic publications in which third party dependencies are an integral component. The workflow within each of the sprints was designed to capture data from the participants during each phase of submission and evaluation for a publication.

During an initial evaluation phase, the assigned publishers and preservation partners collaborated to perform a detailed review of each publication. Together they defined the core intellectual components of the publication — those that must be preserved for future audiences to fully understand the work's substance and arguments. Publishers provided detailed instructions for the playback or reading experience of the material submitted. They described what an intended audience should be able to do when the archived content is made available in the future. These core intellectual components served as acceptance criteria for the success of the work done in subsequent phases. In addition, description and documentation of these components gave preservation providers a more complete understanding of the context and dependencies for a work.

In the preservation action phase, each publication was analyzed by one or two preservation services. A series of tools and techniques was applied, including normalization of export packages, web archiving (LOCKSS, Heritrix, Brozzler, Squidwarc, Memento Tracer, and Browsertrix), and emulation (EaaSI). Preservation specialists determined which of the publication's required core components could be preserved and to what degree the approach might be scalable. Works that progressed through the preservation actions were moved forward for assessment.

The Portico and CLOCKSS model is to provide access to ("trigger") a scholarly work if it is no longer available through any publisher. The services register their triggered copy with CrossRef so that researchers will be redirected to the preserved copy if using the DOI. This makes access an important consideration for both services, and so evaluating the rendition copy for fidelity of the core intellectual components was one component of this analysis. Though there are risks that occur over time as technologies change, if the sample rendition is not close to matching the publisher requirements, then the preservation is challenged from the outset. Publishers received a mixture of mockups and actual preservation packages for what the items could look like if triggered for access. They tested them to determine whether the required and preferred features were captured appropriately, and they answered questions related to the playback experience of the preservation copy of a work. This process captured the degree to which the archived content matched the preservation goals and expectations about what would be preserved. The preservation services documented what was preservable using current tools. They recorded any constraints such as technical limitations, scalability of the approach, or limits on what was feasible in the time frame provided. 20 complex works were analyzed to determine their preservability at scale. Among them were 17 works from six different publishing software platforms, plus three websites that were constructed to present a single work. Though these works represent a diverse sampling, some cross-cutting themes emerged, each with implications for preservation strategy. The key themes are described here.

Together, the project team recorded lessons learned from each work. They made note of patterns that supported preservation and modifications that a publisher could have made during the creation of the original work to improve the preservability of the

material while maintaining the essential aspects of the content. This formed the basis of the guidelines [2] for improving the preservability of these works. In turn, the preservation specialists documented their boundaries. They identified the effort required to create each new preservation workflow, as well as the likelihood that the approaches could be replicated at scale. The team also noted improvements to both the publishers' and preservation services' existing workflows that could help accommodate future requests and improve efficiency.

III. Results and Observations

Resources Not Supplements

Both CLOCKSS and Portico preserve supplemental files that are provided with a publication, but the majority of traditional publications do not have any. Where they do have supplements, they are typically few in quantity, rarely have comprehensive metadata, and are sometimes not included in export packages sent for preservation. Most of the publications analyzed not only include additional resources but have an unusually large quantity and diversity of them. Of the 20 publications analyzed, 17 have files in addition to the main text, 11 have over 100 files, and five have over 400. Resource types include text, image, audio, video, software, and a wide variety of data files. *Developing Writers in Higher Education* [3], for example, includes 283 PDFs, 31 videos, 22 audio files, and three images in addition to the EPUB for the text, totaling 5.9GB.

The text plus these resources are considered to be the work. In four platforms analyzed, structured descriptive metadata is applied to these resources. Each has a dedicated landing page within the platform, and in some cases, a persistent identifier is assigned to support independent citation. When looking at how these resources relate to the main text, they are either: visually embedded in the text; linked directly from the text using the landing page URL; or unlinked supplements available with the main text to provide context. Two platforms, Fulcrum and Manifold, refer to these additional files as "resources" and the others call them "files," which implies a more ambiguous relationship to the text than supplements. Conversations with the publishers confirmed that this distinction is intentional.

Increasingly, funded research requirements prescribe sharing supporting evidence for a publication. This project showed that the traditional lines between text, figures, and supplements continue to blur with "figures" being independently citable artifacts and "supplements" being a vital part of the work. For preservation purposes, the inclusion of these resources in the publishers' exports, the addition of structured metadata, and use of persistent identifiers is helpful. While working with the publishers, the preservation services highlighted the advantages of using non-proprietary, broadly adopted file formats where possible, but recognize that the innovative nature of the works means there will likely always be unexpected formats in the archive. The addition of descriptive metadata is especially helpful in these instances. Also challenging is to ensure that these works, which are internally a map of linked resources, are captured appropriately with all components and the relationships between them intact.

Preservation Strategy Considerations

For the preservation services, the complexity, volume, and variety of formats within a single work presents a challenge for managing and eventually supporting access to the work. First, the diversity of file types highlights the importance of collective efforts such as PRONOM to ensure a high proportion of the files can be identified and matched to an appropriate rendition approach in the future. Second, preservation services will need to consider how to arrange these complex composite works in the archive to ensure they are manageable, discoverable, and eventually accessible. In some cases, it may be practical to keep the entire work in a single Archival Information Package (AIP) and focus on extracting and indexing metadata to reveal the component resources. Alternatively, it may be more elegant to atomize a complex work so that each component resource has its own AIP with links and relationships between the resources recorded in structural metadata. This atomization would allow for flexibility in package management (for versioning individual resources, migration etc.) and more closely reflects how they are managed on the publisher platforms. Finally, the treatment of resources as citable artifacts adds complexity to rights management. Traditional publishing workflows manage the rights for embedded figure graphics in the context of the work, but if managing hundreds of resources that can be viewed independently or as one, the rights status must be

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defined through the structured metadata or constrained through the publishing workflows in order for preservation decisions to be possible at scale.

Resources Embedded via Iframes

One of the most frequent challenges found within the publications analyzed was the use of HTML iframes to visually embed the content of a webpage into a work. Iframes are present in the majority of the works reviewed during this project. They are primarily used for media players, user contributed content, or data visualizations such as maps. It is technically simple to embed web content in web content, and generally acceptable to use iframes on the live web without procuring rights for the embedded content. Attempting to copy and archive these features, however, presents a variety of challenges. This content may be lost without coordination between the publisher and the preservation service.

Three key factors related to iframes affect the options for publishers and preservation services. The first factor is the format of the publication. The research focused on EPUBs and web-based publications[1]. For EPUBs, the technical challenges are more complex than for web-based publications. The EPUB specification [4] allows iframes but requires that a fallback reference be defined since a reader may not support them. Iframes were found in five of the 10 EPUBs evaluated and were used by two of the three publishers that produced EPUBs. None of the iframes in the examples had fallbacks. This dependency needs careful management if the publication is to be preserved.

A second factor is whether the iframe resource is on the publisher's platform or a third-party platform e.g. YouTube. If using a third-party platform, the long-term viability for the content improves if it is uploaded and managed by the publisher, and original files and metadata are retained in case the third-party version becomes unavailable. If a work is a composite of webpages on multiple platforms all managed by the publisher and all original files are intact, it becomes plausible to craft processes that pull content together for preservation. Using iframes to include third party platforms not managed by the publisher is challenging both technically and legally.

In several examples with YouTube videos that weren't managed by the publisher, the content became unavailable after publication. In this respect, use of third-party platforms to embed things is not just a preservation challenge but one of sustainability for the publisher since the content can disappear before a preservation service is involved.

The final factor is how dynamic the iframe content is. All iframe resources are referenced using a URL. In some cases, all relevant data is loaded when the URL first loads. In others, a limited and predictable set of interactions may load all necessary data (e.g. click play). Either of these may be possible to archive with a web crawler if the original files are unavailable or not sufficient to represent the functionality of the iframe. When iframe content is highly dynamic, that is, when user interaction depends on perpetual communication with the server, it can be difficult to preserve. In these cases, resources are composed of an open-ended number of possible URLs that vary by user interaction. Typical examples of features that are dynamic in this way are map visualizations, IIIF viewers, and search features for which each user interaction loads a new response from the server. The more dynamic a resource is, the less likely it can be preserved at scale in website form. The only option may be for the publisher to provide the underlying data and/or software for the resource if available. Website preservation will be discussed further in The Experience of the Work section below.

One of the challenges in articulating guidelines for handling iframes was identifying their characteristics and mapping them to the methods for mitigating loss. If using a web crawler to preserve a web-based publication with an iframe featuring a simple static HTML page hosted on the publisher's platform, the iframe is likely inconsequential to the preservation approach. The same static HTML page in an iframe within an EPUB presents a more complicated challenge to harvest and then associate the page with the EPUB file. If the iframe contains dynamic data-driven content or exists on a third-party platform not managed by the publisher, the challenges are multiplied.

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[1] Some EPUBs were both downloadable and presented on the website using an EPUB reader; the online version is considered web-based.

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Preservation Strategy Considerations

For services that aim to preserve these forms of scholarship, building a strategy for iframes depends on the combination of the factors described. Ideally publishers would keep track of the use of iframes in publications or label them so that domain names or URLs that are in scope for crawls can be easily identified by preservation services. Where the preservation copy must cross boundaries of formats in order to cover the content (for example, where iframes are embedded in an EPUB, or data files are supplied for a visualization that cannot be copied), preservation services will need to consider the appropriate strategy for each format and ensure the metadata tracks the links and relationships between the original iframe URL and archived resources. Considering how to present these parts in a way that is useful for future scholars helps focus this work on ensuring all data necessary to do this is collected.

Living Documents

Managing and connecting versions of content over time is a common digital preservation challenge. In traditional academic publishing, a DOI or ISBN is assigned to a particular version of record. While imperfect [5][6], this rigidity has been useful for those who preserve scholarship in supporting review of content for duplication and completeness. Discussions about versioning of scholarly contributions that fall outside of traditional workflows have been developing for a number of years in communities like Force11. Similarly, this research highlighted the need to record new versions of scholarly works outside of the traditionally controlled correction and retraction workflows.

Perpetual Drafts

Two of the 20 publications evaluated were in draft state during the assessment. On Revaluation of Value on the Manifold platform is in a perpetual draft state and may remain that way indefinitely with occasional updates. The publisher indicated that even though publications on the Manifold platform were in draft state, it was important not to wait until they were officially "published" to preserve them since the draft state and iterative approach to the work may be intentional.

User Contributed Content

Seven of the works had user contributed comments or annotations. Annotations and highlighting are built into the Manifold platform, and the landing page for each book integrates Tweets that have referenced the publication. *Rhizcomics* [7] from Michigan Publishing features both a Disqus comments integration and a Hypothesis annotation toolbar. While this content was considered nice-to-have for preservation in most examples, some publishers explained that for certain cases this was an important piece of the work. Some annotations were added by the authors after publication and others held useful context.

Preservation of user contribution features has technical, legal, and ethical challenges. When managed within the platform software, there is more flexibility since publishers can incorporate language to support preservation into the Terms of Service. It also allows for data export and migration of user contributed content to new platforms. Many third-party integrations for comments and annotations are tied to the URL and may be at risk of loss if the URL changes. When a third-party service is used, their platform Terms may hinder preservation. Even if the content is legal to preserve - Hypothesis users, for example, implicitly agree to make public content CC0 licensed [8] by using the platform - unless moderated, there is nothing to prevent users from posting copyrighted content. In the case of integrations such as Twitter feeds, copying an account handle, photo, and Tweet content without the permission of the author prompts ethical and legal concerns. For these reasons, inclusion of user-contributed content for the purpose of preservation must be weighed against the risk factors. Where this content is considered vital and is covered by Terms, it instead becomes a versioning challenge within which parts of the content might change while its identifier remains the same.

Preservation Strategy Considerations

For works with non-traditional requirements for versioning, preservation services and publishers should discuss what parts of the publication might change and over what period, then establish criteria for determining when to preserve a new copy. Many of the works in this research were large with numerous component parts. Efficient versioning criteria combined with workflows that only update the files that have changed can avoid unnecessary redundancy and overuse of storage. If versioned content is eventually triggered by the preservation service, there will need to be a mutual understanding about which version(s) should be made available for access.

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The Experience of the Work

Traditional digital publications primarily simulate print publications; they consist of static linear text broken up by sections and images. Many of the works analyzed for this project present users with a carefully crafted dynamic experience. The publisher's impression of how much of this experience should be preserved varied for each work. Conversations to understand the scope of the experience that should be preserved were critical to determining the most efficient approach for preservation. With publications on Fulcrum, for example, the specific experience offered by the platform was viewed as less important than preserving the component parts and connections between them so that they could be reassembled on a future platform. Three other works, whose platform was designed as part of the publication, offer a unique experience that is fundamental to understanding the creator's intent. RavenSpace also has a number of important interactive features that are difficult to separate from the platform (the popup agreement asking that visitors are respectful guests, the ability to search the site using the First Nations keyboard, and the non-linear style of navigation).

For these works, if it can be performed with reasonable accuracy and at scale, a web harvested version can be the most efficient way to copy the work and then quickly re-render it using a WARC player to maintain elements of the original experience. A useful aspect of the CLOCKSS and Portico service model is the option to spend time customizing a solution to match a platform's unique features. In each of the platforms analyzed for web harvesting (Manifold, Fulcrum, Scalar, and RavenSpace), a fully automated crawl without any site-specific configuration did not record all of the features that were considered vital to the experience of the publication. None of these platforms include sitemaps, and so, a mixed strategy was applied to ensure the crawlers visited all of the URLs that made up the publication's vital functionality. For Manifold and Scalar, the open API was used to create a sitemap and additional configuration was added to ensure URLs that result from key user interactions (e.g. opening out the menu levels on Scalar) were retrieved. CLOCKSS utilized the LOCKSS technology for the crawls, while Portico tested a selection of browser-based crawlers, with Brozzler used most frequently. Ultimately the biggest challenges were

the same across all crawler tools - archiving highly dynamic features in which the combination of URLs that make up the feature cannot be reasonably predicted using a script. Data driven search interfaces, IIIF viewers, and map visualizations, for example, were consistently missed from web crawls since these load new URLs based on specific user interactions.

A final experiment to test options for preserving the experience involved recreating two of the most dynamic publications on virtual machines so that their websites could be emulated in the future. This was attempted for *As I Remember It* [9] and *Filming Revolution* [10], since web harvesting attempts fell short for these two. The publications, both built on LAMP stacks, had to be adapted for encapsulation. This took several days for each [11] and involved copying dependencies (multimedia, fonts, etc) to a local directory on the machine and then updating the code to point to those directories. Once encapsulated, the machines were loaded into the EaaSI platform and tested with the Internet connection disabled. For both publications, the playback via EaaSI was at a very high quality that met all of the publisher's requirements. While a preservation service is unlikely to apply significant code edits as part of their usual services, our purpose here was to understand the effort of encapsulation and confirm that this approach might be feasible during initial development of the project with little to no extra work if the developer is aware of the preservation and sustainability implications of external dependencies. In one illustrative example, a site's load function was called when its Google font loaded successfully. If Google stopped supporting that font, the site would stop working and a developer would have to determine why. If the publisher did not have a developer available to analyze the issue, the publication might be taken offline. Using a local non-proprietary font would have eliminated this risk. When the project is preserved, these challenges are transferred to the preservation service, and repairing websites does not scale well across hundreds or thousands of projects.

Preservation Strategy Considerations

There are a diverse set of tools for website archiving, and many support extensive customization at the platform level. It is clear that customization can go a long way to improving the quality of web crawling, and for services working with

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specific publishers, knowing the platform is an important advantage. The challenge then becomes monitoring the quality of crawls over time to ensure the tools maintain an accurate crawl, and that platform changes are detected and remain preservable.

In some cases, platforms are too dynamic to be harvested using a web crawler, and the only option for preserving the experience is server-side preservation. While creating a virtual machine to replicate a one-off project like *Filming Revolution* seems appropriate, it is more complicated to envision how to do this efficiently across thousands of works from the same platform since preserving thousands of virtual machines would be very costly. In theory, a virtual machine containing a pre-installed publisher platform could be prepared, along with a short script to bootstrap a work into it. The theory is untested, and scalability is contingent on highly consistent packages from the publisher. The packages seen during this research did not meet this requirement but had potential. If successful, this may be the most efficient approach to preserving the experience of some of the most complex works from publisher platforms.

IV. Conclusion

Enhancing Services to Preserve New Forms of Scholarship set out to determine what aspects of enhanced dynamic scholarship could be preserved at scale. In the majority of examined works, with preservation services giving individual attention to each, it was possible to identify an approach that would be acceptable for the publisher. The exceptions were those in which a significant portion of the work was dependent on a third-party service and there was no way (legally, ethically, and within the timeframe for the analysis) to copy that content or represent it locally in a more preservable form.

While preservation approaches could be applied to navigate challenges within individual works, it was the scalability aspect that introduced the biggest constraints. As workflows were retested on different projects from the same platform, some patterns around what scaled were revealed. The overall structure and text of a work can be captured consistently if (a) it follows a predictable template or conforms to format standards and best practices and (b) it is possible to spend time configuring preservation workflows that align with that template. For example, if standard HTML conventions are

followed for hyperlinks and multimedia, these may be easily crawled using a standard web crawler without additional configuration. In most cases, however, the features that caused the work to meet the criteria for inclusion in this project were the ones whose implementation varied widely, making them challenging to preserve at scale and at the highest risk of loss. The novelty of these features in a publishing context means there are few standards or best practices for how to integrate them into the work in a form that makes it easy to design scalable workflows for preservation. When configuring a workflow for this kind of content, the preservation services must therefore depend on patterns established in examples provided. If a single feature strays from the patterns established during the configurations, the workflow could miss important components and possibly do so without detection. In many instances, the features that tended to introduce unpredictability in the quality of preservation were inside iframes. These often hold content that makes the work unique and so cannot be broadly excluded, but also represent the biggest challenge to managing the scalability of the preservation process.

As is often the case with digital preservation, technical challenges were also sometimes surpassed by legal or even ethical questions (in the case of user-contributed content) around whether the content should be preserved. With no automated way to make the distinction, an excess of caution around undefined license status can lead to significant and unnecessary loss.

The level of effort for building a scalable approach for preservation was also a challenge. Capturing the core features of each work in a multi-publication platform took weeks instead of days due to the complexity of the works. Spending weeks to develop a unique configuration might be an acceptable level of effort for broadly adopted platforms, but is much less scalable or affordable if there are many different platforms with a small number of works on each or a lot of inconsistency between each work. Add to this challenge building in quality control to detect minor variations between templates, and the effort required for high quality preservation at scale may become insurmountable.

A remedy to these scalability challenges is for publishers, authors, and platform developers to introduce some uniformity and emphasize approaches that will support automation in

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preserving the works. The guidelines that resulted from this project were conceived to facilitate a conversation between preservation services and those that create complex enhanced scholarly works to enable the creators and curators of the works to play a role in planning for preservation.

We recognize that these guidelines will likely be difficult for the most under-resourced publishers to implement, which may compound the existing challenge of preserving works from smaller publishers. Moving forward, the project team will continue to partner with those involved in developing commonly used open source platforms so that changes made for preservation at the platform level can be felt by all users of the platform. If the preservation and publishing communities can coalesce around some standard approaches and continue this conversation as innovations progress, the preservation services can make changes to their services to improve support for new forms of scholarship that will scale.

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