Issue Statement

Software obsolescence poses a major threat to the preservation of born-digital records. New advancements in emulation technology are beginning to offer at-scale solutions to this problem. However, with these solutions come new legal and ethical concerns. I advocate for the creation of a national registry and licensing body for obsolete software and more standardized description practices.

Issue Paper: Emerging Solutions and New Challenges in Software Preservation

While digital preservation is now a well-established field within libraries, archives and museums (LAMs), the more niche, yet equally important role of *software* preservation remains underfunded, under-supported and under-recognized. Nevertheless, for reasons both technological and social, software preservation efforts have recently reached an important inflection point, and as old technical problems are finally being solved, new legal, ethical and practical challenges are beginning to arise. In this paper, after documenting the necessity and difficulty of software preservation, I examine the impact of emerging emulation technologies rooted in networked, shared access to obsolete software. Finally, I advocate for more widespread institutional awareness of software preservation issues, the creation of a national registry and licensing body for obsolete software and more standardized descriptive practices for born-digital objects.

1. Why Software Preservation Matters

LAMs preserve software for two primary reasons: first, as a tool to access the complex digital objects in their collections and second, to facilitate the study of software as an object itself. The first, utilitarian purpose of software preservation grants archivists and users the ability to decipher text files in obsolete formats, maintain the full functionality of program files, or access visualizations without substantially altering the original display of the images.[1] The accessibility of legacy data relies heavily on the ability to retain the "software dependent

[1] Euan Cochrane, "Rendering Matters-Report on the Results of Research into Digital Object Rendering," *Archives New Zealand*, 2012, accessed March 31, 2019, http://archives.govt.nz/sites/default/files/rendering_matters.pdf.

elements" in their original display environments.[2] Further, this utilitarian use is also becoming increasingly important in examining the reproducibility of scientific experiments and the accuracy of archived datasets. Scientific processes and equipment increasingly rely on customized and unique software specifications, and thus the preservation of this code is essential to the verifiability of the resulting scientific data. As Douglas Thain, Peter Ivie, and Haiyan Mengoutline explain in a 2015 report, "unfortunately, this [reliance on computers] has made the problem of scientific reproducibility even harder, due to the complexity and imprecision of specifying and recreating the computing environments needed to run a given piece of software."[3] Without extensive continuous efforts to document computing environments and preserve legacy software, we are in danger of forever losing access to important cultural and scientific information.

The second purpose of software preservation, the study of software as a subject itself, is producing a growing body of important scholarly research in a wide range of academic disciplines. For instance, Mathew Kirschenbaum's *Track Changes* examines the influence of word processing software on the history of writing[4] and recent scholarly work by Erica Robles-Anderson and Patrik Svensson explores how the ubiquity of PowerPoint "provides a common infrastructure, a template for the organization of speech, and for the logic of argumentation."[5] Universities around the world continue to add new programs and degrees in the field of Game

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[2] Kendra Albert, "A Victory for Software Preservation: DMCA Exemption Granted for SPN," *Cyberlaw Clinic* (blog), October 26, 2018, accessed March 20, 2019, http://clinic.cyber.harvard.edu/2018/10/26/a-victory-for-software-preservation-dmca-exemption-granted-for-spn/.

[3] Douglas Thain, Peter Ivie, and Haiyan Meng, "Techniques for Preserving Scientific Software Executions: Preserve the Mess or Encourage Cleanliness?," in *Proceedings of the 12th International Conference on Digital Preservation (IPRES)*, 2015, 164–174. https://daspos.crc.nd.edu/images/reports/techniques-ipres-2015.pdf, 1.

[4] Matthew G. Kirschenbaum, *Track Changes* (Harvard University Press, 2016).

[5] Erica Robles-Anderson and Patrik Svensson, "'One Damn Slide After Another': PowerPoint at Every Occasion for Speech," *Computational Culture*, no. 5 (2016), http://computationalculture.net/one-damn-slide-after-another-powerpoint-at-every-occasion-for-speech/.

Studies[6] and since 2009, MIT Press has regularly published new scholarly texts under their Software Studies Series.[7] For these burgeoning fields of scholarship to continue, researchers must have access to accurate and complete "complex digital objects" in their original computing environments.[8] Every day, computers play a more central role in all manners of cultural production, from visual art, music and time-based media to engineering, healthcare, transportation and particle physics. Thus, maintaining a trustworthy record of this cultural output necessitates the accurate and reliable preservation of the software used to produce and access it.

2. The Unique Technical Challenges of Software Preservation

While traditional physical media objects like books, photographs and film can last for centuries with proper storage and care, born-digital objects like software tend to have a much shorter lifespan.[9] In addition to the physical and material decay known as "bit rot," digital objects like executable program files are also highly susceptible to format obsolescence. As a recent report from the Association of Research Librarians points out, "because of the rates at which digital media deteriorates and digital technology shifts, our ability to access software just a few years after its release is highly endangered—and the knowledge that depends on that software is therefore at risk."[10] Paired with the degradation of physical media, the rapid rate of technological change in computing entails that digital preservationists must devote a

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[6] For example, see *USC Games*, https://games.usc.edu/ and *NYU Game Center*, https://gamecenter.nyu.edu/academics/. For a more comprehensive accounting of the emerging academic discipline of game studies see Bonnie Ruberg, "Getting a Game Studies PhD: A Guide for Aspiring Video Game Scholars," Blog, *Our Glass Lake* (blog), last updated March 2018, http://ourglasslake.com/getting-into-game-studies/.
[7] MIT Press, "Software Studies," accessed March 20, 2019, https://mitpress.mit.edu/books/series/software-studies
[8] Allen Foster and Pauline Rafferty, *Managing Digital Cultural Objects: Analysis, Discovery and Retrieval* (Neal-Schuman Publishers, 2016), 24. Foster and Rafferty define "complex digital objects" as "discrete digital objects that are made by combining a number of other digital objects, again accompanied by identifying metadata."
[9] Jean-François Blanchette, "A Material History of Bits," *Journal of the American Society for Information Science and Technology* 62, no. 6 (2011): 1042–1057.
[10] Patricia Aufderheide et al., "The Copyright Permissions Culture in Software Preservation and Its Implications for the Cultural Record" (Association of Research Libraries, February 9, 2018), https://www.arl.org/storage/documents/2018.02.09_CopyrightPermissionsCulture.pdf., 5

considerable amount of their time, resources and energy to maintaining, updating and preserving the software in their collections, even when it is only a few years old.[11]

Moreover, as software becomes obsolete and digital objects become unreadable on contemporary machines, digital preservationists must find new ways to access older files. For decades, this issue has primarily been addressed by migrating data to updated formats that are accessible through contemporary computers with backwards compatibility.[12] For example, using specialized hardware and digital forensics tools, archivists can create disk images of floppy disks that are then interpretable by non-obsolete software. But while migration has been a successful strategy in stabilizing and storing some otherwise at-risk information, it proves inadequate for providing access to more complex digital objects or preserving software itself. As Stewart Granger explains, "[migration] has both dangers and costs. The notable danger is that of data loss, or in some cases the loss of original functionality or the look and feel of the original platform."[13] While there are many programs that offer backwards compatibility with older file formats, recent research has shown that "when files are rendered in environments that differ from the original then they will often present altered information to the user."[14] Thus, it is not enough to migrate and store data, archivists must also preserve the computing environment in which that data is rendered. As digital objects have become more complex and increasingly dependent on specific hardware and software requirements, migration, in turn, has become a less viable and useful option for preservation.

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[11] Shira Peltzman personal interview with the author, Los Angeles, November 29, 2018.
[12] Dianne Dietrich et al., "How to Party Like It's 1999: Emulation for Everyone," *The Code4Lib Journal*, no. 32 (April 25, 2016), http://journal.code4lib.org/articles/11386.
[13] Stewart Granger, "Emulation as a Digital Preservation Strategy," *D-Lib Magazine* 6, no. 10 (October 2000), https://doi.org/10.1045/october2000-granger.
[14] Cochrane, "Rendering Matters-Report on the Results of Research into Digital Object Rendering."

Moreover, software preservation poses a unique challenge due to the lack of institutional infrastructure and support, and the inadequacy of an institution-by-institution approach. As UCLA Library Digital Archivist Shria Peltzman indicated in a recent interview, in digital preservation "access usually comes last…it's a can people keep kicking down the road."[15] At UCLA Libraries, curators often accession collections containing born-digital objects without a firm understanding of the software and infrastructure requirements needed to provide authentic access to those objects.[16] Through an extensive survey conducted in 2014, the Software Preservation Network (SPN) found that "there is a professional awareness of the importance of software preservation, but very few organizations have been prepared to embark on software preservation projects of their own."[17] And furthermore, as a report from the ARL concludes, "most [institutions] cannot support a comprehensive library of software, expert staff, and related tools."[18] The huge scale of this problem necessitates a more collaborative approach. For all these reasons, LAMs are now turning to new, shared, collective, at-scale solutions.

3. Emerging Solutions – Emulation as a Service

To approach the problem of obsolescence at scale, software preservationists are beginning to move away from a model focused on migration and backwards compatibility to a new model rooted in emulation. Emulation is not a new technology, and it has been used for preservation and access purposes dating back to at least 1995, including, most famously, in

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[15] Peltzman, personal interview with the author, Los Angeles, November 29, 2018.
[16] For example, Peltzman noted that UCLA Library Special Collections has accessioned multiple collections containing complete Macintosh computers, but the digital archive currently has no way to disk image the hard drives of these machines and lacks the proper obsolete computing environment (hardware and software) to open many of the files.
[17] Jessica Meyerson et al., "The Software Preservation Network (SPN): A Community Effort to Ensure Long Term Access to Digital Cultural Heritage," *D-Lib Magazine* 23, no. 5/6 (May 2017), https://doi.org/10.1045/may2017-meyerson.
[18] "Best Practices for Fair Use in Software Preservation," The Software Preservation Network, accessed December 9, 2018, http://www.softwarepreservationnetwork.org/bp-fair-use/.

Emory University's processing of the Salman Rushdie papers in 2007.[19] However, due to its prohibitive costs and advanced technical knowledge requirements, it has only recently become a viable and accepted option for preservation among LAMs more generally.[20] A full technical explanation of emulation is beyond the scope of this paper, but essentially it is a means by which a "virtual machine" is implemented on a host computer. This implementation can then run "unmodified software binaries" designed for the system running on that virtual machine.[21] In other words, by virtually imitating a specific configuration of hardware and "machine code," emulation allows for software code to be run on computers on which it could normally never run.

Since 2016, a number of promising emulation-based initiatives have launched, aiming to preserve legacy software and reshape the way researchers access obsolete digital materials. Most notably, a project recently initiated at the Yale University Libraries (YUL), in partnership with the Software Preservation Network (SPN), utilizes and builds upon an emulation framework developed at the University of Freiberg known as BwFLA – Emulation-as-a-Service (EaaS).[22] In EaaS, the virtual machines used for emulation are hosted on networked servers, and cloud computing technologies allow for remote users to access pre-configured hardware and software environments through the web.[23] As Digital Preservation Manager at YUL Euan Cochrane explains, "the power of and value of the EaaS approach…is that it abstracts away the details of which emulator is being used and how it is configured, and

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[19] Dan Rockmore, "The Digital Life of Salman Rushdie," *The New Yorker,* July 29, 2014, https://www.newyorker.com/tech/annals-of-technology/digital-life-salman-rushdie.
[20] Dianne Dietrich et al., "How to Party Like It's 1999: Emulation for Everyone," *The Code4Lib Journal*, no. 32 (April 25, 2016), http://journal.code4lib.org/articles/11386.
[21] David S.H. Rosenthal, *Emulation & Virtualization as Preservation Strategies*, a report commissioned by The Andrew W. Mellon Foundation, New York, October 2015, https://mellon.org/Rosenthal-Emulation-2015
[22]"BwFLA: Emulation as a Service," accessed March 16, 2019, http://eaas.uni-freiburg.de/.
[23] Rosenthal, "Emulation & Virtualization as Preservation Strategies,"

simply provides the preconfigured emulated computers for use in archival/library workflows."[24] In other words, EaaS allows minimally trained archivists to use a wide range of emulators to configure computing environments through simple web-based interfaces. The original EaaS framework has already been used successfully to provide remote users with access to obsolete software in past projects, most notably in Rhizome and the New Museum's popular 2016 online exhibition of Theresa Duncan's 1990s CD-ROM games.[25]

At YUL, Software Preservation Program Manager Seth Anderson is working on a three-year, grant-funded project to scale up this EaaS framework to serve a broader range of users, establishing EaaS "nodes" at other major collecting institutions around the country. Launched in late 2018, the Scaling Emulation and Software Preservation Infrastructure (EaaSI) program "is focused on the development of technology and services that support distributed management, documentation, sharing, and use of emulated software across a broad range of disciplines."[26] Simultaneously, through SPN's "Fostering Communities of Practice" initiative, over the next three years, pilot projects at six institutions will "experiment and test emulation software, confront specific issues such as legal, metadata, technical preservation, and access challenges specific to their projects, and ideally bring software preservation and access into the mainstream of digital preservation practice."[27] In theory, EaaSI will allow LAMs around the country to collectively store, document and share access to the obsolete software in their collections. So, rather than each institution needing a full suite of obsolete hardware and software to extract,

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[24] Euan Cochrane, Jonathan Tilbury, and Oleg Stobbe, "Adding Emulation Functionality to Existing Digital Preservation Infrastructure," *Journal of Digital Media Management* 6, no. 3 (2018): 255–264, 258.
[25] "The Theresa Duncan CD-ROMs," *Rhizome,* accessed March 16, 2019, http://archive.rhizome.org/theresa-duncan-cdroms/.
[26] "About EaaSI – Saving Software Together," Software Preservation Network, accessed March 16, 2019, https://www.softwarepreservationnetwork.org/eaasi/.
[27] "About FCoP – Saving Software Together," Software Preservation Network, accessed March 15, 2019, https://www.softwarepreservationnetwork.org/fcop/.

migrate and maintain their legacy digital objects, they could simply implement "a node" of the EaaSI infrastructure and allow users to access digital material using an emulated computer environment in person, or in a web-based "virtual reading room."[28] This increased access to born-digital objects through emulated computing environments will force archivists to rethink many of their standard practices regarding arrangement, description, metadata, and copyright.

4. New Intellectual Property Right Concerns

The first major roadblock facing this new form of software preservation is copyright law. While shared, distributed access to obsolete software would solve many of the preservation and access issues listed above, as Seth Anderson admits, it also "obviously raises some questions in regard to legality."[29] According to Anderson, digital preservationists interested in developing EaaS are well-aware of the potential intellectual property right concerns in expanding widespread access to copyrighted software, and to this point, they have mostly relied on an expansive understanding of the fair use doctrine in their practices. Accordingly, because fair use is such a notoriously slippery and complex legal concept, in early 2017, the ARL was awarded a grant to develop and disseminate a *Code of Best Practices in Fair Use for Software Preservation*.[30] The *Code*, released in September 2018, evaluates the application of the fair use doctrine in five of the most common software preservation activities, and finds that "fair use applies to institutions making software available on a cooperative basis to broaden research opportunities, including off-premises access using technology such as Emulation as a Service."[31]

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[28] Euan Cochrane, "Designing a Universal Virtual Interactor (UVI) for Digital Objects - Digital Preservation Coalition," Digital Preservation Coalition, accessed March 16, 2019, https://www.dpconline.org/blog/idpd/designing-a-uvi-for-digital-objects.
[29] Seth Anderson, Skype interview the author, November 29, 2018.
[30] "Code of Best Practices in Fair Use for Software Preservation," Software Preservation Network, accessed March 31, 2019, https://www.softwarepreservationnetwork.org/bp-fair-use/
[31] Association of Research Libraries, "Code of Best Practices in Fair Use for Software Preservation," revised February 22, 2019, accessed April 1, 2019, https://www.arl.org/storage/documents/2019.2.28-software-preservation-code-revised.pdf, 11.

However, the code also lists four major limitations to the application of fair use in this case. These limitations all focus on the creation and necessity of specific policies regarding how, when and to whom access to emulated software environments should be granted. Thus, as EaaS technologies mature and become more widely available, it will be essential for institutions to begin building the relevant policies and institutional guidelines around researcher access to emulation and shared software. This will require more widespread awareness of the problems of software preservation issues throughout the profession.

My informal conversations with digital preservation professionals, coupled with a review of surveys from within the field,[32] indicate that despite the legitimate intellectual property right concerns, archivists must work towards establishing a more centralized, open, shared national repository for legacy software using EaaS. This repository should be a joint project of the SPN, the software industry and perhaps the National Software Reference Library.[33] Otherwise, because fair use applies only to obsolete and commercially unavailable software, as new software continues to flood the market, LAMs will always be playing catch-up in their effort to maintain the necessary tools to preserve born-digital materials. A more collaborative, national effort to not only document, but properly store and preserve new software is necessary. Digital preservation metadata registries such as PREMIS, PRONOM and wikidata offer promising starts to the documentation of file formats and software, but it is not enough to simply know the technical specifications of a digital object, archivists also need the capacity for continued, reliable access. In order to address these concerns, LAM professionals will need to go beyond a

[32] Aufderheide et al., “The Copyright Permissions Culture."
[33] The National Software Reference Library is a program of the US Department of Homeland Security and the National Institute of Standards and Technology that collects software from various sources and “incorporate[s] file profiles computed from this software into a Reference Data Set (RDS) of information.” “National Software Reference Library,” accessed March 31, 2019, https://www.nist.gov/software-quality-group/national-software-reference-library-nsrl.

reliance on the fair use doctrine and advocate for major changes to section 108 of the copyright law. Moreover, within the EaaS community, there is already a move to create a new licensing model that would treat emulation more like a performance, similar to music streaming. As Cochrane explains, this would allow LAMs to "address licensing by establishing similar organizations to manage it as exist for music. i.e. performance rights organizations (PROs)."[34] The establishment of a central, national organization tasked with licensing software "performance" would be a major step towards clarifying the often confusing and unclear ownership issues that come with outdated and unclear software licensing agreements or orphaned software.

5. Describing Born-Digital Objects in an Age of Emulation

In addition to these copyright concerns, EaaS also brings new archival description and metadata requirements. In a 2018 study, Digital Assets Specialist at the American Folklife Center, Julia Kim observes and documents the way different access methods affect researchers' interaction with digital objects. By examining "different types of emulated, migrated and 'as-is' access on both contemporary and obsolete computers," Kim's study demonstrates that emulation technologies can play a major role in shaping the way researchers understand archival materials.[35] Kim explains that "all researchers commented on the tangible, even visceral experience of the emulation and its departure from contemporary computing."[36] Thus, the study indicates the importance of accurate and transparent description practices for these access methods. Because there are multiple

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[34] Erin Engle, "Intellectual Property Rights Issues for Software Emulation: An Interview with Euan Cochrane, Zach Vowell, and Jessica Meyerson | The Signal," webpage, January 22, 2016, //blogs.loc.gov/thesignal/2016/01/intellectual-property-rights-issues-for-software-emulation-an-interview-with-euan-cochrane-zach-vowell-and-jessica-meyerson/.
[35] Julia Kim, "Researcher Access to Born-Digital Collections: An Exploratory Study," *Journal of Contemporary Archival Studies* 5, no. 1 (May 25, 2018), https://elischolar.library.yale.edu/jcas/vol5/iss1/7, 1.
[36] Kim, 9.

competing and experientially different methods for accessing born-digital files, it is essential for those methods to be explained and divulged to researchers. In summarizing the results of her findings, Kim suggests that archivists "must preserve bit-exact disk images of collections, software, and documentation of dependencies, behavior and donor intent in order to secure the potential for emulation for access and preservation."[37] In other words, emulation is coming, and we must prepare by accurately documenting the necessary information for its future use. Additional studies of emulation use, especially Dianne Dietrich et al.'s 2016 article "How to Party Like it's 1999: Emulation for Everyone," have also come to similar conclusions on the necessity of clear documentation and description practices for methods of access.[38]

Along these lines, one major effort to help bolster standardization and collaboration within born-digital description was recently launched through the publication of the "UC Guidelines for Born-Digital Archival Description."[39] Responding to a "dearth of internal policies and procedures for born-digital archival description," the authors consulted the most widely used archival standards (ISAD(G), DACS, and EAD) and found "a number of areas where real-world processing practices conflicted with standards."[40] In response, the four digital archivists produced a new set of guidelines that, among other recommendations, stress the importance of the "Processing Information Section" on any finding aid that describes born-digital materials. The authors recognize that born-digital materials can be

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[37] Kim, 11.
[38] Dietrich et al., "How to Party Like It's 1999."
[39] University of California Systemwide Libraries. (2017). *UC Guidelines for Born-Digital Archival Description. UC Office of the President: University of California Systemwide Libraries.* Retrieved from https://escholarship.org/uc/item/9cg222jc.
[40] Annalise Berdini et al., "Describing Digital: The Design and Creation of a Born-Digital Archival Description Standard at the University of California Libraries," *Journal of Western Archives* 9, no. 1 (September 7, 2018), https://digitalcommons.usu.edu/westernarchives/vol9/iss1/10, 5.

processed and accessed in vastly different ways, and that this contextual information is vital for researchers to understand. As Berdini et al. explain, "processing legacy born-digital material can often involve changing the nature of the data to preserve it and make accessible…it is essential that this information be recorded to ensure that future archivists and users understand … the process by which they are able to access the materials."[41] As EaaS becomes more technically and economically feasible, archivists will need to adjust their description practices and finding aids to account for these new access methods. Building off the principles established in the "UC Guidelines", finding aids of the future will need to describe not only how born-digital materials were accessioned and processed, but also the computing environment and technological context of access. The finding aid of the future will likely look quite different from those used today, and if current trends continue, an accurate description of the process and meaning of software emulation will need to be a part of that finding aid.

6. Conclusion

EaaS cannot solve all the problems of software obsolescence, and these tools come with their own set of thorny new preservation issues going forward. For instance, emulation is itself dependent on software and hardware compatibility and thus susceptible to platform and media obsolescence. Even as the emulation framework becomes more standardized and distributed through EaaSI, archivists must be sure to properly document and preserve changes to the emulators and maintain interoperability with current systems. Moreover, as born-digital objects become more complex and more closely tied to specific hardware requirements (such as multi-touch screens, VR headsets, or other accessories) archivists will need to become familiar with the additional metadata and operational requirements for

[41] Berdini et al., 8.

"authentic" playback and access. And finally, the preservation of web-dependent and cloud-based software will require an even more collaborative and collective effort to ensure future access to digital material. Software obsolesce has plagued digital preservation efforts for decades, but the technologies needed to address this issue are finally beginning to emerge. Archivists and collecting institutions need to be aware of the issues surrounding this new technology so that it can be successfully integrated into archival workflows and infrastructure in the future.

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