CHRONOPOLIS AND METAARCHIVE: PRESERVATION COOPERATION

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ABSTRACT

This paper will examine ongoing work between two major preservation systems, the Chronopolis Digital Preservation Program, [6] and the MetaArchive Cooperative. [13] In the past year, these two systems have begun work on bridging their technical underpinnings to create a more robust, reliable, long-lived preservation community for their users. The main emphasis of this work is moving data between a LOCKSS-based system (MetaArchive) and an iRODS-based one (Chronopolis). This work also involves several other emerging preservation micro-service tools and practices, and the expertise of the University of North Texas (UNT) Digital Library [21] in deploying them. The final result of this work is intended to be of three-fold benefit: 1) directly improving the services offered by Chronopolis and MetaArchive to their constituents; 2) offering specific technical findings which will be of benefit to other systems using LOCKSS and iRODS; and 3) contributing to the larger preservation community through the examination of organizational best practices for preservation system interactions.

1. BRIDGING METAARCHIVE AND CHRONOPOLIS

Large-scale digital preservation is a core technology need in many communities worldwide. The majority of information is now produced as digital files, rather than print output. To prevent the loss of significant cultural and scientific assets, active preservation systems must be put into place. This is not a theoretical threat: on a daily basis, data collections are lost for myriad reasons. The reasons for this range from the smallest and most mundane to the catastrophic, and they cannot be totally prevented–they are unavoidable in any large technology enterprise. Thus there is a core need to preserve data as rigorously as possible to make it live into the future.

Several projects and technologies are now focused on this need. Two of the most successful projects and their corresponding open source technologies are the Chronopolis Digital Preservation Program making use of the Integrated Rule-Oriented Data System (iRODS) [9] and the MetaArchive Cooperative making use of the Lots Of Copies Keeps Stuff Safe (LOCKSS) platform. [11]

1.1. Chronopolis and iRODS

Chronopolis is a digital preservation data grid framework developed by the San Diego Supercomputer Center (SDSC) at UC San Diego, the UC San Diego Libraries (UCSDL), and their partners at the National Center for Atmospheric Research (NCAR) in Colorado and the University of Maryland's Institute for Advanced Computer Studies (UMIACS).

A key goal of the Chronopolis framework is to provide cross-domain collection sharing for long-term preservation. Using existing high-speed educational and research networks and mass-scale storage infrastructure investments, the partnership is designed to leverage the data storage capabilities at SDSC, NCAR and UMIACS to provide a preservation data grid that emphasizes heterogeneous and highly redundant data storage systems.

Specifically, the current partnership calls for each Chronopolis member to operate a grid node containing at least 50 TB of storage capacity for digital collections related to the Library of Congress' National Digital Information Infrastructure and Preservation Program (NDIIPP). [14] For reference, just one terabyte of information would use up all the paper made from about 50,000 trees. The Chronopolis methodology employs a minimum of three geographically distributed copies of the data collections, while enabling curatorial audit reporting and access for preservation clients. The original underlying technology for managing data within Chronopolis has been the Storage Resource Broker, [20] a preservation middleware software package that allows for robust management of data. The partnership is also developing best practices for the worldwide preservation community for data packaging and transmission among heterogeneous digital archive systems.

Chronopolis has concentrated on building a wide range of content that is not tied to a single community. Currently there are four significant collections housed in Chronopolis. These include:

- A complete copy of the data collection from The Inter-university Consortium for Political and Social Research (ICPSR), based at the University of

Michigan. Established in 1962, ICPSR is the world's largest archive of digital social science data. [10]

- Data from The North Carolina Geospatial Data Archiving Project, a joint project of the North Carolina State University Libraries and the North Carolina Center for Geographic Information and Analysis. It is focused on collection and preservation of digital geospatial data resources from state and local government agencies in North Carolina. [15]
- Scripps Institution of Oceanography at UC San Diego (SIO) has one of the largest academic research fleets in the world, with four research vessels and the research platform FLIP. Since 1907, Scripps oceanographic vessels have played a critical role in the exploration of our planet, conducting important research in all the world's oceans. SIO is providing data from several decades of data from its cruises. [18]
- The California Digital Library (CDL) is providing content from its "Web-at-Risk" collections. Web-at-Risk is a multi-year effort led by CDL to develop tools that enable librarians and archivists to capture, curate, preserve, and provide access to web-based government and political information. The primary focus of the collection is state and local government information, but may include web documents from federal and international government as well as non-profit sources. [5]

Chronopolis is currently transitioning from the use of SRB to iRODS. One of the hallmarks of iRODS is its rule-based architecture. On top of an advanced preservation environment, this rule-based architecture allows iRODS administrators to create a customized environment that follows designated rules and triggers specific actions based on certain events.

The rule-based process has three layers. The most granular layer is a system of micro-services. In the iRODS context, micro-services are functions that have been written to accomplish a certain task. A large set of micro-services ships with the default iRODS installation, but additional ones can be written by iRODS systems administrators as needed in their particular environment.

Micro-services can be chained together to form longer processes called actions. Actions are macro-level tasks that typically call on multiple micro-services. Actions are called or started based on predefined rules. These rules are tasks that the iRODS system needs to perform when certain conditions are met. The iRODS system has a built-in rule-engine that then interprets rules and calls the underlying actions (and hence the micro-services) when appropriate.

An example of an iRODS rule: when a new file of type x is added to the system, rename it adding a timestamp to its filename and copy it to another location. The rule in this case is calling two actions (renaming process and copying process). Each of these actions consists of multiple micro-services (which do the actual underlying work to make changes to the file and file system).

1.2. The MetaArchive Cooperative and LOCKSS

Originally created as an initiative of the US National Digital Information Infrastructure and Preservation Program (NDIIPP), the MetaArchive Cooperative is a distributed, nonprofit-based alliance of university libraries, archives, and research centers. The Cooperative's purpose is to support, promote, and extend distributed digital preservation practices. Since 2004, the MetaArchive Cooperative has provided community-owned and community-governed digital preservation activities through running a distributed preservation network that is based on the LOCKSS software.

To preserve digital assets, the MetaArchive Cooperative uses a systemic, forward-looking technological approach called distributed digital preservation. The member institutions identify collections that they want to preserve. They then ready these collections for preservation, creating Submission Information Packages (SIPs). Using a technical framework that is based on the LOCKSS software, these collections are then ingested into a geographically distributed network where they are stored on secure file servers in multiple locations that are housed by the member institutions. These servers do not merely back up the materials. Rather, they provide a dynamic means of constantly monitoring content via the LOCKSS software and its use of ongoing cryptographic SHA-1 hashes to compare the copies, determine if any have degraded in any way, and then provide repairs whenever necessary. Such redundancy and monitoring activities minimize the risk that information might be lost due to human error, technology failure, or natural disaster.

The Cooperative currently is comprised of seventeen member institutions that preserve their digital collections in a 254 TB network that is distributed internationally at thirteen distinct sites. The network grows both in content and in size as new members join the Cooperative. Its membership doubled in 2009, and it is expected to double again in 2010.

The Cooperative's mission is twofold: 1) providing distributed digital preservation services for its member organizations and 2) having an impact on the broader cultural memory field through modeling the use of open source technology and community-based infrastructures to accomplish digital preservation in ways that can be replicated by other groups.

To these ends, the Cooperative maintains transparency in its operations and makes available to other groups that seek to implement preservation solutions all of its administrative and technical developments. In this way, the Cooperative has fostered the formation and growth of other Private LOCKSS Networks (PLNs), [17] including the Persistent Digital Archives and Library System (PeDALs) initiative, [16] the Alabama Digital Preservation Network (ADPNet), [1] and the Data-PASS network, [7] run by the Interuniversity Consortium for Political and Social Research (ICPSR) at the University of Michigan. [10] It also recently published a book, *A Guide to Distributed Digital Preservation*, [19] which is

intended to help other groups form and run their own distributed digital preservation networks.

1.3. UNT and CDL Micro-Services

Beyond these two successful projects and technologies, yet another new suite of preservation and curation tools that are proving integral to this work is being hosted at the California Digital Library (CDL), named the Curation Micro-Services. [4] According to the University of California's Curation Center, "micro-services are an approach to digital curation based on devolving curation function into a set of independent, but interoperable, services that embody curation values and strategies." These small and self-contained services span the range between providing persistent URLs, unique identifiers, file system conventions, fixity checking, format migration and file transfer specifications, among many others.

The University of North Texas (UNT) was chosen as the key bridge technology partner in this interoperability work because they have demonstrated the great potential for putting these and several other micro-services into unbundled and modular use on behalf of transporting and managing digital objects and collections. UNT has constructed a robust and loosely integrated set of in-house archiving infrastructures to manage their own digital collections, including a delivery system (Aubrey) and a repository structure (CODA). The underlying file system organization of digital objects is tied to a UNT-specific data modeling process that relies on locally developed scripts and CDL micro-services to generate and define all master, derivative, related objects, metadata, and other information that may be tied to a single digital object in order to effect timely archival management and access retrieval. This archival repository solution has been designed in a highly open source fashion and relies on loosely bundled specifications to ensure on-going flexibility and scalability.

1.4. Scope of Work

Each of these sets of technologies has strengths and weaknesses, but one action that would improve them all is the ability to transfer preserved objects between systems based on these technologies. Making this possible would offer a more robust suite of interoperable tools and allow preservation systems to leverage the power of each technology in a modular fashion. It would also enable practitioners using these systems to take advantage of tools and services created by any of these technologies.

The focus of this paper is to examine one instantiation of this transfer process, using already existent collections and trustworthy processes. The work that has already been done, and which will refined in the coming year, is based on daily use of the MetaArchive LOCKSS-based and the Chronopolis iRODS-based systems, and making use of BagIt, [2] a CDL micro-services based component, and other modular approaches, to efficiently facilitate a transfer. The collections being utilized are real, and the processes represent actual tasks.

The work being described has been made possible thanks to a grant provided by the National Historical Publications and Records Commission (NHPRC). The work put forth has been to successfully identify the necessary technologies and workflows needed to efficiently retrieve and package a complete collection from a LOCKSS file system, through the use of custom developed scripts and the BagIt specification, and maintain its archival unit integrity both structurally and at the file object level while transferring into a non-LOCKSS based environment for the purposes of providing a succession pathway. Fixity checking is required on the collection prior to initial retrieval from the LOCKSS file system, and validation is required both prior to packaging, and upon un-packaging on its destination directory registered in the iRODS storage environment managed by Chronopolis. Additional effort will be made to explore the packaging and transfer requirements for the MetaArchive's data management tool, known as the Conspectus, [12] as well as its associated collection level metadata.

2. STAGE ONE: COMPLETE

Chronopolis and MetaArchive have completed an initial round of testing the process of sharing data between their systems. This first round focused on transferring data from the MetaArchive LOCKSS-based system into Chronopolis' SRB-based system. This was done using two different transfer approaches.

2.1. BagIt-Based Transfers

First, the BagIt tool was used as a simple proof-of-concept on behalf of four test collections of data of approximately 200MB. BagIt is a simple packaging specification that incorporates a human-readable manifest file. This file lists the digital objects in the package as well as their checksums and serves as an authoritative inventory list. Between July 15 and August 11, 2009 system administrators from the MetaArchive and Chronopolis worked together to transfer archival units (AUs), measuring in the 100s of MBs, from the MetaArchive network into the Storage Resource Broker using what are known as BagIt files. The BagIt file specification allows for a regular bag and a "holey bag." A regular bag bundles up the actual data in a file directory, while a holey bag uses URLs that point to the data and performs an extraction.

These BagIt transfers (four Bag files in all) were of a small enough size to facilitate unsophisticated http "get" requests and even an email-based transfer to get the AUs into Chronopolis' SRB-configured storage environment. Upon completion the administrators verified the successful transfer of these individual Bags into SRB, ran checksum-based comparisons on the Bag content, and registered the content into their MCAT

database (which captures and holds metadata that can be exported later for data provider purposes).

2.2. SRB Client-Based Transfers

Following this initial test with BagIt, An additional transfer was performed using a combination of custom-written and SRB-based client scripts as well as BagIt. Chronopolis staff first provided a script that gathered MetaArchive content into a "holey" bag. The SRB-specific scripts that function as Unix commands were then used to facilitate a "put" of those files to the MetaArchive's directory in SRB.

The MetaArchive system administrator was then required to download and install the client and set-up two specific files: an Environment file and an Authentication file:

- The Environment file sets up user credentials for the home directory on the assigned SRB storage environment. This is the location to which a Bag can be sent and unpackaged for quality control.
- The Authentication file stores a password to manage access to this environment.

2.3. Lessons Learned from Initial Transfers

Several lessons were learned from these initial processes, which are informing next steps for the project.

- MetaArchive staff had to iteratively work through several authentication and registration issues when setting up appropriate working and home directories in the designated SRB instance.
- During holey BagIt tests there were minor extraction issues related to LOCKSS. LOCKSS puts a '#' character in the directory structure that it creates. The '#' is treated as an html anchor, and this causes problems during a web transfer. To surmount this it was necessary to URL encode the '#' and turn each one into a '%23'.
- MetaArchive AUs and/or complete collections must be taken out of active preservation mode and be rendered static before being placed into Bags and transferred to Chronopolis, otherwise the LOCKSS re-crawling and polling/voting process(es) will interfere with their packaging.

Also, based on these lessons, several areas of refinement were designated for the next stage of work:

- The need to measure transfer rates as data flows between the systems, especially to help determine if one method is more efficient or provides better service.
- Usability comparisons between use of an SRB (now iRODS) client transfer and that of a manual send/get of BagIt files through standard web channels.
- Transferring collections in excess of 1TB to achieve large-scale efficiency.

3. STAGE TWO: CURRENT PROCESSES

Based on what was learned in these initial steps, the current processes were begun, with several guiding principles in mind. The first of which regarded the feasibility of transferring MetaArchive collections on a larger scale to Chronopolis's data grid environment (now running on iRODS) it was decided to do so at a larger AU or collection level. SRB and iRODS, using BagIt, can handle ingests of content in the multiple TB range.

From an ease of packaging and transfer perspective, it was initially encouraged to use a true bridge server (non-LOCKSS based), so that content can be migrated in a static condition via the LOCKSS content serving feature or through a WARC, ARC or ZIP extraction. Bags can then be generated and sent from this bridge server via an installed iRODS client. This avoids interference from the routine LOCKSS operations on a cache that may impede a transfer.

Based on these recommendations, beginning in April 2010, efforts were begun to improve the transfer of MetaArchive collections through addressing the items listed above. This phase of work is relying on Chronopolis' new iRODS configuration, but still makes use of BagIt as the primary transfer mechanism.

3.1. Larger Collection

For this phase a new, larger MetaArchive collection has been designated. The Folger Shakespeare Library has agreed (through an MOU) to permit the use of a copy of their 1.5TB collection currently being preserved in the MetaArchive network. A MetaArchive-LOCKSS cache located at the University of North Texas (UNT) will harvest this collection. A developer from UNT will prepare the Folger digital collections for transfer to Chronopolis, manage this transfer with tests for content integrity and authenticity, and address the above lessons learned and areas for refinement. Staff at Chronopolis will coordinate with UNT's staff to receive, validate, and preserve the Folger content, and also facilitate with addressing the above "objectives."

3.2. Stage Two Summary of Work

The following tasks are slated for completion in this current work process:

- UNT will bring up its MetaArchive cache in consultation with MetaArchive staff;
- UNT will harvest the Folger Shakespeare Library collection, and validate its integrity through the LOCKSS voting/polling measures;
- UNT will collaborate with Chronopolis to transfer the Folger collections from MetaArchive's LOCKSS-based network to Chronopolis's iRODS-based preservation service and back again.

This work will serve is serving as a proof-of-concept that the MetaArchive network may use Chronopolis's iRODS-based preservation service as an exit strategy in the event that either MetaArchive or LOCKSS becomes unsustainable in the future.

3.3. Stage Two Summary of Progress

As of July 2010, the following measures have been accomplished ahead of enacting a full-scale second transfer of MetaArchive collection content into the Chronopolis environment:

- UNT configured a 50TB server on-site as a MetaArchive-LOCKSS cache in order to host the 1.3TB Folger collection;
- UNT coordinated with MetaArchive member GA Tech to proxy export the full Folger collection and metadata onto its MetaArchive-LOCKSS cache;
- UNT's cache participated a full round of LOCKSS-driven file voting/polling validation and ensured 100% integrity of Folger collection content;
- UNT developed and tested a custom script that exploits the in-built LOCKSS content serving features and standard HTTP protocols, and relies upon open source micro-services such as httplib2, Beautiful Soup, and other Python libraries to retrieve and validate the Folger files, and package each archival unit according to the "holey" BagIt specification;
- Chronopolis has provided and configured an iRODS client tool for UNT and registered a storage resource within their San Diego SuperComputer Center data node environment;
- Preliminary transfer rates were tested on a 6GB archival unit subset of Folger collection content and it was determined that the entire 1.3 TB could be transferred over the course of a 48 hour period;
- UNT, Chronopolis and MetaArchive staff began evaluating requirements for ensuring that the Conspectus data management tool and its associated collection level metadata could be exported into the Chronopolis environment.

3.4. Additional Work

In addition, discussion has begun between the groups toward developing strategies for how data can be transferred out of Chronopolis' iRODS environment and into MetaArchive's LOCKSS based storage. So far this has involved a preliminary examination of which iRODS rules may be necessary to stage the sharing of data between an iRODS and a LOCKSS environment. This analysis will continue to involve developing a better understanding of the differences in file systems, file naming conventions, directory structures, and file movements within the systems. Each of these differences will likely impact the kinds of micro-services, actions and rules that are needed. We anticipate that some of the available default micro-services will be part of the process, but that significant custom work will also be needed. In addition the project will need to keep track of which metadata is specific to each of the systems and which might need to be added or modified based on the iRODS actions.

4. FUTURE WORK

The ability for different digital preservation solutions to interoperate is necessary to reach the goal of long-term preservation of digital resources. The interchange of content between two repositories such as the MetaArchive Cooperative and Chronopolis stands as a use case for future work in the area of interoperability of digital preservation system for sustainability purposes. The work that will be accomplished in the next year lays the groundwork for future detailed, deep work to share preservation objects among diverse systems. Several specific next steps in this area include having a better understanding of the optimal granularity of units being passed between the two systems, identifying any needed data management implementations for ensuring best practices for administrative, technical, structural and preservation metadata, as well as the requirements that end users may have for retrieving archived content from these preservation networks and re-creating collections at their local institutions.

REFERENCES

[1] Alabama Digital Preservation Network (ADPNet). Available at: http://www.adpn.org/

[2] BagIt File Packaging Format. Available at: http://www.cdlib.org/inside/diglib/bagit/bagitspec.html

[3] Beautiful Soup. Available at: http://www.crummy.com/software/BeautifulSoup/

[4] California Digital Library: Curation Micro-Services. Available at: http://www.cdlib.org/services/uc3/curation/

[5] California Digital Library: "Web-at-Risk". Available at: http://www.cdlib.org/services/uc3/partners/webatrisk.html

[6] Chronopolis: Preserving Our Digital Heritage. Available at: http://chronopolis.sdsc.edu/

[7] Data Preservation Alliance for the Social Sciences (Data-PASS). Available at: http://www.icpsr.umich.edu/icpsrweb/DATAPASS/

[8] Httplib2. Available at: http://code.google.com/p/httplib2/

[9] Integrated Rule-Oriented Data System (iRODS). Available at: http://www.irods.org/

[10] Inter-university Consortium for Political and Social Research (ICPSR). Available at: http://www.icpsr.umich.edu/icpsrweb/ICPSR/

[11] Lots of Copies Keep Stuff Safe (LOCKSS). Available at: http://www.lockss.org/lockss/Home

[12] MetaArchive Conspectus Tool. Available at: http://conspectus.metaarchive.org/archives/list

[13] MetaArchive Cooperative. Available at: http://metaarchive.org/

[14] National Digital Information Infrastructure and Preservation Program (NDIIPP). Available at: http://www.digitalpreservation.gov/library/

[15] North Carolina Geospatial Data Archiving Project. Available at: http://www.lib.ncsu.edu/ncgdap/

[16] Persistent Digital Archives and Library System (PeDALS). Available at: http://pedalspreservation.org/

[17] Private LOCKSS Networks. Available at: http://lockss.stanford.edu/lockss/Private_LOCKSS_Networks

[18] Scripps Institution of Oceanography at UC San Diego (SIO). Available at: http://scripps.ucsd.edu/

[19] Skinner, Katherine and Matt Schultz Eds. *A Guide to Distributed Digital Preservation*, Educopia Institute, Atlanta, GA, 2010. Available at: http://www.metaarchive.org/GDDP

[20] Storage Resource Broker (SRB). Available at: http://www.sdsc.edu/srb/index.php/Main_Page

[21] University of North Texas Digital Library. Available at: http://digital.library.unt.edu/