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Linked Archival Metadata: A Guidebook

draft Draft Draft! Draft!!! DRAFT!!! D R A F T ! ! !

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1. Executive Summary

[The Executive Summary will list core objectives, anticipated outcomes, and implications that will provide administrators or other senior leaders with the information that they will need in order to understand the benefits and potential costs of this path.]

2. Introduction

This is a travel guide – a set of itineraries for getting from here to linked data and the Semantic Web. It outlines the sorts of things you may want to know if you want to get from here to someplace else. There are many ways to get there. None of them are perfect. Each of them have their own particular strengths & weaknesses, opportunities & impediments. If you want to go on this journey at a cost of, say, \$10 per day, then there are a number of options for you. If you want to spend \$25 dollars per day, then a number of other options available. If you want to spend as much as \$50 day, then there are quite a number of other options. This guide book will use this metaphor throughout the text so you can evaluate your options.

For all intents and contexts, linked data and linked open data are synonymous, but the subtle difference does need to be discussed. Linked open data is a qualification of linked data. Linked open data comes with an explicit license agreement denoting how the accessible data can be “freely” used. In this case, the words “free” and “open” are analogous to free “open source software”. Just as open source software is available for use and re-use, linked open data is free for use and re-use. Attribution needs to be made. The data can be freely used. While copyrights may still be in place when it comes to linked open data, the copyrights allow for the use, re-use, and re-distribution. The intent of linked open data is to use the content in ways that it can be used in many ways for many purposes. While the distinction between linked data and linked open data are may be large in the eyes of some people, for simplicities sake, the phrase linked data is synonymous with linked open data, even though some feel the distinction needs to be delineated to a greater degree.

Implementing linked data represents a different, more modern way of accomplishing some of the same goals of archival science. It is a process of making more people aware of your content. It is not the only way to make more people aware, but it represents a way that will be wide spread, thorough, and complete.

Linked Archival Metadata: A Guidebook provides archivists with an overview of the current linked data landscape, define basic concepts, identify practical strategies for adoption, and emphasize the tangible payoffs for archives implementing linked data. It focuses on clarifying why archives and archival users can benefit from linked data and will identify a graduated approach to applying linked data methods to archival description.

The Guidebook is a product of the Linked Archival Metadata planning project (LiAM), led by the Digital Collections and Archives at Tufts University and funded by the Institute of Museum and Library Services (IMLS). LiAM’s goals include defining use cases for linked data in archives and providing a roadmap to describe options for archivists intending to share their description using linked data techniques.

02.a How to use the Guidebook

The structure of the Guidebook supports readers moving through the text in a variety of ways. Like a travel book, it provides useful high-level information for users who only need the basics, as well as in-depth information for those planning an extended stay in LOD-land. The Guidebook is intentionally named, and will draw from the genre of actual travel guides (Fodors, etc.) providing readers easy access to both high-level information (know before you go, what to see if you're only there for a day) as well as in-depth details of for those staying in one place longer.

Synopses of the use cases developed by the LiAM project will be interspersed throughout the Guidebook to illustrate and frame the text. Each use case will be briefly described in 100-200 words with links to the full use cases on the LiAM website.

An initial release of the Guidebook will be in the form of a PDF document to be delivered to IMLS in fulfillment of the LiAM planning grant requirements as well as being shared with the public. However, the Guidebook's ongoing vitality will benefit from a more dynamic publication environment, and we therefore plan to publish it in a wiki connected to a code repository. This combination will enable updating of the resource to reflect changes in the field as well as providing a mechanism for sharing tools, scripts, and other code related to the project.

Much of the rest of the Guidebook, while providing a concise overview of today's linked data landscape and needs, would require ongoing updates, maintenance, and enhancement to describe implementation of LOD in the archival community over time.

3.a. Objectives: management, access, and use and linked data affordances

[Management, access, and use and linked data affordances]

2.a Use cases

What can you do with linked data once it is created? Here are three use cases:

1. Do simple publishing - At its very root, linked data is about making your data available for others to harvest and use. While the “killer linked data application” has seemingly not reared its head, this does not mean you ought not make your data available as linked data. You won’t see the benefits immediately, but sooner or later (less than 5 years from now), you will see your content creeping into the search results of Internet indexes, into the work of both computational humanists and scientists, and into the hands of esoteric hackers creating one-off applications. Internet search engines will create “knowledge graphs”, and they will include links to your content. The humanists and scientists will operate on your data similarly. Both will create visualizations illustrating trends. They will both quantifiably analyze your content looking for patterns and anomalies. Both will probably create network diagrams demonstrating the flow and interconnection of knowledge and ideas through time and space. The humanist might do all this in order to bring history to life or demonstrate how one writer influenced another. The scientist might study ways to efficiently store your data, easily move it around the Internet, or connect it with data set created by their apparatus. The hacker (those are the good guys) will create flashy-looking applications that many will think are weird and useless, but the applications will demonstrate how the technology can be exploited. These applications will inspire others, be here one day and gone the next, and over time, become more useful and sophisticated.

2. Create a union catalog - If you make your data available as linked data, and if you find at least one other archive who is making their data available as linked data, then you can find a third somebody who will combine them into a triple store and implement a rudimentary SPARQL interface against the union. Once this is done a researcher could conceivably search the interface for a URI to see what is in both collections. The absolute imperative key to success for this to work is the judicious inclusion of URIs in both data sets. This scenario becomes even more enticing with the inclusion of two additional things. First, the more collections in the triple store the better. You can not have enough collections in the store. Second, the scenario will be even more enticing when each archive publishes their data using similar ontologies as everybody else. Success does not hinge on similar ontologies, but success is significantly enhanced. Just like the relational databases of today, nobody will be expected to query them using their native query language (SQL or SPARQL). Instead the interfaces will be much more user-friendly. The properties of classes in ontologies will become facets for searching and browsing. Free text as well as fielded searching via drop-down menus will become available. As time goes on and things mature, the output from these interfaces will be increasingly informative, easy-to-read, and computable. This means the output will answer questions, be visually appealing, as well as be available in one or more formats for other computer programs to operate upon.

3. Tell a story - You and your hosting institution(s) have something significant to offer. It is not just about you and your archive but also about libraries, museums, the local municipality, etc. As a whole you are a local geographic entity. You represent something significant with a story to tell. Combine your linked data with the linked data of others in your immediate area. The ontologies will be a total hodgepodge, at least at first. Now provide a search engine against the result. Maybe you begin with local libraries or museums. Allow people to search the interface and bring together the content of everybody involved. Do not just provide lists of links in search results, but instead create knowledge graphs. Supplement the output of search results with the linked data from Wikipedia, Flickr, etc. You don’t have to be a purist. In a federated search sort of way, supplement the output with content from other data feeds such as (licensed) bibliographic indexes or content harvested from OAI-PMH repositories. Identify complementary content from further afield. Figure out a way for you and they to work together to create a newer, more complete set of content. Creating these sorts of things on-the-fly will be challenging. On the other hand, you might implement something that is more iterative and less immediate, but more thorough and curated if you were to select a topic or theme of interest, and do your own searching and story telling. The result would be something that is at once a Web page, a document designed for printing, or something importable into another computer program.

2.a Why linked data, and why now?

Linked data, or more recently referred to as “linked open data” for reasons to be explained later, is a proposed technique for generating new knowledge. It is intended to be a synergy between people and sets of agreed upon computer systems that when combined will enable both people and computers to discover and build relationships between seemingly disparate data and information to create and discover new knowledge.

In a nutshell, this is how it works. People possess data and information. They encode that data and information in any number of formats easily readable by computers. They then make the encoded data and information available on the Web. Computers are then employed to systematically harvest the encoded data. Since the data is easily readable, the computers store the data locally and look for similarly encoded things in other locally stored data sets. When similar items are identified relationships can be inferred between the items as well as the other items in the data set. To people, some of these relationships may seem obvious and “old hat”. On the other hand, since the data sets can be massive, relationships that were never observed previously may come to light, thus new knowledge is created.

Some of this knowledge may be trivial. For example, there might be a data set of places -- places from all over the world including things like geographic coordinates, histories of the places, images, etc. There might be another data set of people. Each person may be described using their name, their place of birth, and a short biography. These data sets may contain ten's of thousands of items each. Using linked data it would be possible to cross reference the people with the places to discover who might have met whom when and where. Some people may have similar ideas, and those ideas may have been generated in a particular place. Linked data may help in discovering who was in the same place at the same time and the researcher may be better able to figure out how a particular idea came to fruition.

Here's an example hitting closer to the home of archives and archivists. Suppose most archival finding aids were written in a format easily readable by computers. Let's call this format Encoded Archival Description. Let's suppose these finding aids were made available on the Web. Let's suppose one or more computers crawled these archival sites harvesting the finding aids. Once done a computer program could be used to find all the occurrences of particular name and generate a virtual finding aid that is more complete and more comprehensible than any single finding aid on that particular person.

The amount of data and information accessible today is greater in size than it has ever been in human history. Using our traditional techniques of reading, re-reading, writing, discussing, etc. is more than possible to learn new things about the state of the world, the universe, and the human condition. By exploiting the current state of computer technology is possible to expand upon our traditional techniques and possibly accelerate the mass of knowledge.

2.a Benefits

Linked data makes the content of archival collections more accessible and open doors for new types of service.

Archives are about collecting, organizing, preserving, and disseminating original, unique, and primary literature. These are the whats of archival practice, but the hows of archival practice evolve with the changing technology. With the advent of ubiquitous networked computing, people's expectations regarding access to information and knowledge have changed significantly. Unless institutions like archives change with the times, then the needs previously filled by archives will be filled by other institutions. Linked data is a how of archival practice, and it is one of those changes behooving archives to adopt. It is a standards-based technique for making data and information available on the Web. It is rooted in the very fabric of the Web and therefore is not beholden to any particular constituency. It is a long lasting standard and practice that will last as long as the hypertext transfer protocol is operational.

Making archival descriptions and collection available via linked data will increase the use of those descriptions and collections. It is a form of benign advertising. Commercial search engines will harvest the linked data content and make it available in their search engines. Search engines will return hits to your descriptions and collections driving traffic to you and your site. Digital humanists will harvest your content, perform analysis against it, and create new knowledge or bring hidden knowledge to light. Computer scientist will collect your data, amalgamate it with the data of others, and discover relationship previously unconceived.

You can divide your combined collections and services into two tangible parts: 1) the collections themselves, and 2) the metadata describing them. It is usually possible to digitize your collections, but the result is rarely 100% satisfactory. Digitization is almost always a useful surrogate not a complete replacement. In this way, your collections as physical objects will always be a draw to all types of learners and researchers. The metadata, on the other hand, is 100% digitizable, and therefore lends itself very well to dissemination on the Internet. Linked data represents one way to make this happen.

Few archival collections are 100% complete. There are always pieces missing, and some of those missing pieces will be owned by others. Your collections will have relationship with other collection, but you will not have direct access to those other collections. Some of these relationships are explicit. Some of them are implicit. If everybody were to expose their metadata then those explicit and implicit relationships can become more apparent. Once these relationships are strengthened and become more obvious, interest in the collections will increase accordingly, and the collections will be used to a greater degree. With this increased use will come increased attention, and in turn, a greater measure of success for the collections and services it provides.

From: Ingrid Mason <ingrid.b.mason@gmail.com>
Subject: Re: [LODLAM] quick benefits to hosting institutions
Date: January 22, 2014 at 9:49:47 PM EST
To: lod-lam@googlegroups.com
Reply-To: lod-lam@googlegroups.com

Hi Jody,

If I understand correctly, you're keen to find examples of value generated. I'll give this a whirl... and see if I'm being helpful.

Converting data that already exists, >> providing a data service that a user community seeks to reuse and contribute to (access value).

PeopleAustralia (National Library of Australia) provides permanent, resolvable unique identifiers that link to records about parties, i.e. people or organisations. The authority file at the Library already had, was reused. This data source was enhanced as a result of ANDS funding to identify parties that manage or own research data collections. You'll see that this has increased the capacity for discovery (through collaboration with other data providers). Key contact: Tim Sherratt @wragge

Collaborating with custodians of primary material (collection managers), using third party data (Dbpedia), and finding, identifying and linking entities in the data >> brought to light information that was previously unknown (research value).

LinkedJazz at the Pratt Institute. Finalist in the LODLAM 2013 summit award along with some other folks (for being generally super clever with LOD things). Key contact: Cristina Patuelli @cristinapattuel

Providing insights into the links in your own data >> improve data quality (data value).

Check out Chris McDowall's post on linking data in digitalNZ. @fogonwater

There are other kinds of value in all that. Guess benefits depend on what the strategic goals of the organisation are, and what the research community needs in terms of access.

Hope that helps?

Ingrid

On 23 January 2014 12:55, Jody DeRidder <jody@jodyderidder.com> wrote:

Hi --

I'm looking for selling points for utilizing linked data, for the institutions creating it. I would appreciate being pointed towards demos that show how particular tools can be utilized to provide improved access and use of local content for which linked data exists -- particularly with regards to primary source materials which have been digitized.

Without the "benefits" side of the equation, it's difficult to make a case for the "costs" part of the work, fascinating as it may be.

Suggestions? Please feel free to contact me off list.

Thanks!

Jody L. DeRidderHead, Digital ServicesUniversity of Alabama LibrariesTuscaloosa, AL 35487Phone: 205.348.0511"Hope lies in dreams, in imagination, and in the courage of those who dare to make dreams into reality."--Jonas Salk

3. Linked Data for Archives: a Primer

Linked Data is a process for manifesting the ideas behind the Semantic Web. The Semantic Web is about encoding data, information, and knowledge in computer-readable fashions, making these encodings accessible on the World Wide Web, allowing computers to crawl the encodings, and finally, employing reasoning engines against them for the purpose of discovering and creating new knowledge.

3.c. Brief overview of the history of LOD-LAM

The history of linked data in libraries, archives, and museums is rooted in history of the Semantic Web.

The canonical article describing the Semantic Web was written by Tim Berners-Lee, James Hendler, and Ora Lassila in 2001. The article described the concept of the Semantic Web -- an environment where Internet-wide information was freely available for both people and computers to access with the ultimate purpose of bringing new knowledge to light. At that time, to implement the ideas behind the Semantic Web, many people created RDF/XML files side-by-side with their HTML and saved on Web servers. Around this same time the idea of "Web services" and REST-ful computing were beginning to be articulated by the Internet community. Simply put, Web services and REST-ful computing are/were a way for computers to request and share information over the World Wide Web. Web services and REST-ful computing became popular because just about anybody can do it. All you usually have to do is submit a very long URL plus numerous variable/value pairs to a Web server, and the Web server returns some data. Many computer programmers and people who could write HTML quickly picked up on this idea, and it became popular. Besides, no Semantic Web "killer application" had been demonstrated to the wider Internet community, and many computer technologists thought RDF/XML was a poor way of serializing RDF. The idea of the Semantic Web faded for a few years.

In 2006 Berners-Lee more concretely described how to make the Semantic Web a reality in a text called "Linked Data -- Design Issues". In it he advocated a complementary way for computers to request and share information, namely, a process called "content negotiation". In this process much simpler URLs (easily human-readable "cool URLs") were sent to a Web server as well as a request for the Web server's response to be in a specified format: HTML, PDF, RDF/XML, etc. At this same time additional RDF serializations were becoming popular; RDF/XML was no longer the only way to express RDF. By this time a few entrepreneurial companies were also beginning to provide software services for creating, maintaining, and distributing RDF. These developments, plus the kinship of "all things open" (open source software, open access publishing, and open data) with the fundamental goals of the Semantic Web, probably led to the current interest in linked data.

3.d. Examples

[What is the current interest? A few examples are in order. Mention the activities of OCLC and other large cultural-heritage institutions. Mention the availability of numerous RDF triple stores and data dumps. Mention a few Web services and REST-ful interfaces. Mention a few linked data implementations. Mention the growth of linked data from governments, Wikipedia, etc. Mention the growth of linked data meeting and conferences.]

3.b. Overview of linked data concepts and vocabulary

Linked data is a standardized process for publishing and disseminating information via the Web. It represents the current "how" behind the ideas the Semantic Web.

Increasingly you will hear of linked data being qualified as "linked open data". The "open" qualifier alludes to the important distinctions between truly free data/information and licensed data/information which comes with some strings attached. Truly "open" linked data comes with no licensing restrictions.

When you hear of linked data and the Semantic Web, the next thing you often hear is "RDF" or "Resource Description Framework". First and foremost, RDF is a way of representing knowledge. It does this through the use of assertions (think, "sentences") with only three parts: 1) a subject, 2) a predicate, and 3) an object. Put together, these three things create things called "triples". The subject of each assertion is expected to be a Universal Resource Identifier (or URI, but think URL), and this URI is expected to represent a thing -- anything. (Really, anything.) The predicate is some sort of relationship such as equals or is a sub-part of or contains or is a description of, or is the name of, etc. Predicates are the vocabulary of linked data, and you will find an abundance of vocabularies from which to choose when creating Linked Data. Finally, objects come in two forms: 1) more URIs (pointers to things) or literal values such the names of people, places, or things. Examples of literals include "Lancaster, PA", "Thomas Jefferson", or "Musée d'Orsay".

RDF is not to be confused with RDF/XML or another other type of RDF "serialization". Remember, RDF describes triples, but it does not specify how the triples are express or written down. On the other hand, RDF/XML is an XML syntax for expressing RDF. Some people think RDF/XML is too complicated and too verbose. Consequently, other serializations have manifested themselves including N3 and Turtle.

In "Linked Data -- Design Issues" Berners-Lee outlined four often-quoted expectations for implementing the Semantic Web. Each of these expectations are listed below along with some elaborations:

- * "Use URIs as names for things" - URIs (Universal Resource Identifiers) are unique identifiers, and they are expected to have the same shape as URLs (Universal Resource Locators). These identifiers are expected to represent things such as people, places, institutions, concepts, books, etc. URIs are monikers or handles for real world or imaginary objects.

- * "Use HTTP URIs so that people can look up those names." - The URIs are expected to look and ideally function on the World Wide Web through the Hypertext Transfer Protocol (HTTP), meaning the URI's point to things on Web servers.

- * "When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL)" - When URIs are sent to Web servers by Web browsers (or "user-agents" in HTTP parlance), the response from the server should be in a conventional, computer readable format. This format is usually a "serialization" of RDF (Resource Description Framework) -- a notation looking much like a rudimentary sentence composed of a subject, predicate, and object.

- * "Include links to other URIs. So that they can discover more things." - Simply put, try very hard to use URIs that other people have have used. This way the relationships you create can literally be linked to the relationships other people have created. These links may represent new knowledge.

In the same text ("Linked Data -- Design Issues") Berners-Lee also outlined a sort of reward system -- a sets of stars -- for levels of implementation. This reward system also works very well as a strategy for publishing linked data by cultural heritage institutions such archives. A person gets:

- * one star for making data available on the web (in whatever format) but with an open license, to be Open Data

- * two stars for making the data machine-readable structured data (e.g. excel instead of image scan of a table)

- * three stars for making the data available in non-proprietary format (e.g. CSV instead of excel)
- * four stars for using open standards from W3C (RDF and SPARQL) to identify things, so that people can point at your stuff
- * five stars for linking your data to other people's data to provide context

The whole idea works like this. Suppose I assert the following statement:

The Declaration Of Independence was authored by Thomas Jefferson.

This statement can be divided into three parts. The first part is a subject (Declaration Of Independence). The second part is a predicate (was authored by). The third part is an object (Thomas Jefferson). In the language of the Semantic Web and Linked Data, these combined parts are called a triple, and they are expected to denote a fact. Triples are the heart of RDF.

Suppose further that the subject and object of the triple are identified using URIs (as in Expectations #1 and #2, above). This would turn our assertion into something like this with carriage returns added for readability:

```
http://en.wikipedia.org/wiki/Declaration_of_Independence
was authored by
http://www.worldcat.org/identities/lccn-n79-89957
```

Unfortunately, this assertion is not easily read by a computer. Believe it or not, something like the XML below is much more amenable, and if it were the sort of content returned by a Web server to a Web browser (read "user-agent"), then it would satisfy Expectations #3 and #4 because the notation is standardized and because it points to other people's content:

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:dcterms="http://purl.org/dc/terms/" >

  <!-- the Declaration Of Independence was authored by Thomas Jefferson -->
  <rdf:Description
    rdf:about="http://en.wikipedia.org/wiki/Declaration_of_Independence">
    <dcterms:creator>http://id.loc.gov/authorities/names/n79089957</dcterms:creator>
  </rdf:Description>

</rdf:RDF>
```

Suppose we had a second assertion:

Thomas Jefferson was a man.

In this case, the subject is "Thomas Jefferson". The predicate is "was". The object is "man". This assertion can be expressed in a more computer-readable fashion like this:

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:foaf="http://xmlns.com/foaf/0.1/">
```

```

<!-- Thomas Jefferson is man (a male) -->
<rdf:Description rdf:about="http://id.loc.gov/authorities/names/n7908995">
  <foaf:Person foaf:gender="male" />
</rdf:Description>

</rdf:RDF>

```

Suppose there were smart Linked Data robot / spider. Suppose it crawled both Assertion #1 and Assertion #2, it then ought to be able to assert the following:

```

<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:dcterms="http://purl.org/dc/terms/"
  xmlns:foaf="http://xmlns.com/foaf/0.1/">

  <!-- the Declaration Of Independence was written by
  Thomas Jefferson, and Thomas Jefferson is a male -->
  <rdf:Description rdf:about="http://en.wikipedia.org/wiki/Declaration_of_Independence">
    <dcterms:creator>
      <foaf:Person rdf:about="http://id.loc.gov/authorities/names/n79089957">
        <foaf:gender>male</foaf:gender>
      </foaf:Person>
    </dcterms:creator>
  </rdf:Description>

</rdf:RDF>

```

Looking at the two assertions, a reasonable person can deduce a third assertion, namely, the Declaration Of Independence was authored by a man. Which brings us back to the point of the Semantic Web and Linked Data. If everybody uses URIs (read "URLs") to describe things, if everybody denotes relationships (through the use of predicates) between URIs, if everybody makes their data available on the Web in standardized formats, and if everybody uses similar URIs, then new knowledge can be deduced from the original relationships.

Unfortunately and to-date too little Linked Data has been made available and/or too few people have earned too few stars to really make the Semantic Web a reality. The purpose of this guidebook is to provide means for archivists to do their part, make their content available on the Semantic Web through Linked Data, all in the hopes of facilitating the discovery of new knowledge. On our mark. Get set. Go!

There are a number of challenges in the process. Some of them are listed below, and some of them have been alluded to above:

- * Create useful LOD, meaning, create LOD that links to other LOD. LOD does not live in a world by itself. Remember, the "L" stands for "linked". For example, try to include URIs that are the URIs used on other LOD data sets. Sometimes this is not possible, for example, le with the names of people in archival materials. When possible, they used VIAF, but other times they needed to create their own URI denoting an individual.

- * There is a level of rigor involved in creating the data model, and there may be many discussions regarding semantics. For example, what is a creator? Or, when is a term intended to be an index term as opposed reference. When does one term in one vocabulary equal a different term in a different vocabulary?

- * Balance the creation of your own vocabulary with the need to speak the language of others using their

vocabulary.

- * Consider "fixing" the data as it comes in or goes out because it might not be consistent nor thorough.

- * Provenance is an issue. People – especially scholars – will want to know where the LOD came from and whether or not it is authoritative. How to solve or address this problem? The jury is still out on this one.

- * Creating and maintaining LOD is difficult because it requires the skills of a number of different types of people. Computer programmers. Database designers. Subject experts. Metadata specialists. Archivists. Etc. A team is all but necessary.

3.a. Vocabularies and ontologies

Links describing the why's and wherefore's of LOHAC's vocabulary:

- * <http://archiveshub.ac.uk/locah/2011/03/describing-the-things-the-rdf-terms-used-part-1/>
- * <http://archiveshub.ac.uk/locah/2011/03/describing-the-things-the-rdf-terms-used-part-2/>

Look for vocabularies at Linked Open Vocabularies (LOV) – <http://lov.okfn.org/dataset/lov/>

Consider also Aaron Rubinstiens "Archival collections ontology" – <http://gslis.simmons.edu/archival/arch/index.html>

or maybe The LOCAH RDF Vocabulary = <http://data.archiveshub.ac.uk/def/>

The building blocks of linked data include:

- * URIs pointing to real-world objects: people, places, or things where things can be ideas or just about anything on the Web
- * Ontologies, the language(s) of relationships between the URIs
- * Content to share with the wider world
- * People to do the work
- * Computer technology to manifest the work

Probably one of the more difficult intellectual tasks you will have when it comes to making your content available as linked data will be the selection of one or more ontologies used to make relationship between the subjects and objects of your triples. Probably the easiest way to think about these ontologies is as if they were fields in a MARC record or EAD file. Such an analogy is useful, but not 100% correct. Probably the best way to think of the ontologies is as if they were verbs in a sentence denoting relationships between things – subjects and objects. But if ontologies are sets of “verbs”, then they are akin to human language, and human language is ambiguous. Therein lies the difficulty with ontologies. There is no “right” way to implement them. Instead, there is only best or common practice. There are no hard and fast rules. Everything comes with a bit of interpretation. The application and use of ontologies is very much like the application and use of written language in general. In order for written language to work well two equally important things need to happen. First, the writer needs to be able to write. They need to be able to choose the most appropriate language for their intended audience. Shakespeare is not “right” with his descriptions of love, but instead his descriptions of love (and many other human emotions) resonate with a very large number of people. Second, written language requires the reader to have a particular adeptness as well. Shakespeare can not be expected to write one thing and communicate to everybody. The reader needs to understand English, or the translation from English into another language needs to be complete and accurate.

The Internet, by design, is a decentralized environment. There are very few rules on how it is expected to be used. To a great extent it relies on sets of behavior that are more common practice as opposed to articulated rules. For example, what “rules” exist for tweets on Twitter? What rules exist for Facebook or blog postings. Creating sets of rules will not fly on the Internet because there is no over-arching governing body to enforce any rules. Sure, there are things like Dublin Core with their definitions, but those definitions are left to interpretation, and there are no judges nor courts nor laws determining whether or not any particular application of Dublin Core is “correct”. Only the common use of Dublin Core is correct, and its use is not set in stone.

There are no “should's” on the Internet. There is only common practice.

With this in mind, it is best for you to work with others both inside and outside your discipline to select one or more ontologies to be used in your linked data. Do not think about this too long nor too hard. It is an never-ending process that is never correct. It is only a process that approximates the best

solution.

For simplicity's sake, RDF ontologies are akin to the fields in MARC records or the entities in EAD/XML files. Articulated more accurately, they are the things denoting relationships between subjects and objects in RDF triples. In this light, they are akin to the verbs in all but the most simplistic of sentences. But if they are akin to verbs, then they bring with them all of the nuance and subtlety of human written language. And human written language, in order to be an effective human communications device, comes with two equally important prerequisites: 1) a writer who can speak to an intended audience, and 2) a reader with a certain level of intelligence. A writer who does not use the language of the intended audience speaks to few, and a reader who does not "bring something to the party" goes away with little understanding. Because the effectiveness of every writer is not perfect, and because not every reader comes to the party with a certain level of understanding, written language is imperfect. Similarly, the ontologies of linked data are imperfect. There are no perfect ontologies nor absolutely correct uses of them. There are only best practices and common usages.

This being the case, ontologies still need to be selected in order for linked data to be manifested. What ontologies would you suggest be used when creating linked data for archival descriptions? Here are a few possibilities, listed in no priority order:

- * Dublin Core Terms - This ontology is rather bibliographic in nature, and provides a decent framework for describing much of the content of archival descriptions.

- * FOAF - Archival collections often originate from individual people. Such is the scope of FOAF, and FOAF is used by a number of other sets of linked data. * Friend of a Friend (<http://www.foaf-project.org/>) -

- * Schema.org - This is an up-and-coming ontology heralded by the 600-pound gorillas in the room -- Google, Microsoft, Yahoo, etc. While the ontology has not been put into practice for very long, it is growing and wide ranging.

- * RDF - This ontology is necessary because linked data is manifested as... RDF

- * RDFS - This ontology may be necessary because the archival community may be creating some of its own ontologies.

- * PROV - for provenance information.

- * OWL and SKOS - Both of these ontologies seem to be used to denote relationships between terms in other ontologies. In this way they are used to create classification schemes and thesauri. For example, they allow the implementor to that "creator" in one ontology is the same as "author" in another ontology. Or they allow "country" in one ontology to be denoted as a parent geographic term for "city" in another ontology.

While some or all of these ontologies may be useful for linked data of archival descriptions, what might some other ontologies include? (Remember, it is often "better" to select existing ontologies rather than inventing, unless there is something distinctly unique about a particular domain.) For example, how about an ontology denoting times? Or how about one for places? FOAF is good for people, but what about organizations or institutions?

Another approach is to the data model from other organizations. Since Europeana's data is intended to be available as linked data, then it might be a good model to explore - <http://pro.europeana.eu/edm-documentation> Specifically:

For the archival community, collection level descriptions such as EAD play a major role. They fit neatly under the EDM, in particular the notion of `ore:aggregation` allows for describing archival "fonds". The International Council of Archives just started the discussion about a common conceptual model similar to FRBR or the CRM. In the meanwhile, with the CRM historical facts associated with archival contents can be

described in more detail than just on the EDM level (Stasinopoulou et. al. 2007). Further, collection-level descriptions in Dublin Core are quite convenient and becoming popular for archival descriptions. – <http://ontogenealogy.com/europeana-data-model-edm/>

* VoID (<http://semanticweb.org/wiki/VoID>) -

* OAD Vocabulary - (<http://labs.regesta.com/progettoReload/wp-content/uploads/2013/08/oadNew.html>) - "[Google translation] The definition of an ontology of archival description is needed in order to test the potential of the web of data to archival descriptions. The archival description aims at the representation of a unit of description by collecting, analyzing, organizing and recording the information needed to identify, manage, locate and explain the context and documentary material and the storage systems that produced (ISAD (G)). The ontology of archival description (SRO) has as its goal the formal representation of the descriptions of the individual units of description - understood as objects of their archival descriptions. In particular, the SRO waiver to take into account all the individual elements of these descriptions, in endless variations they present as part of the archival systems in which they are hinged, but instead seeks only to explain the elements of information deemed necessary for the exposure the web of data units of archival description to ensure integration with other datasets published also in format Linked Open Data. SROs, in beta, is expressed in OWL (Ontology Web Language): it takes into account all the elements of archival description in the standard ISAD (G): general international standard archival description, adopted by the ICA (International Council on Archives) integrating them with other information elements not covered by the standard mentioned - as the index entries - and with links to creators and conservative. The formal mechanisms provided by the standard RDF and OWL have made it possible to bring the information elements of archival descriptions expressed in an ontology SROs to "external" concepts representative of traditional archival descriptive and based on the international standard ISAD (G). Since the experiments conducted by the partners of the project ReLoad had as object data encoded on the basis of the framework EAD (Encoded Archival Description), the ontology provides for a specific class OAD "eadElement" designed to encode the information on the element or attribute of the EAD scheme used by the organization that provides data archival description, which is also attributed to the ISAD (G) on the basis of official mapping ISAD (G) - EAD

3.a Content-negotiation, REST-ful style computing, and APIs

It is important to understand the difference between linked data and more proprietary application programmer interfaces. This difference is really between REST-ful interfaces to data and content negotiaion interfaces. REST-ful interfaces are specific to specific websites. Content-negotiation is more universal and does not require API keys or the knowledge of name-value pairs. Linked data computing techniques is our HTTP. REST-ful interfaces need to be learn and are all different from one another. Linked data is more universal.

3.b RDF serializations

RDF can be expressed in many different formats, called “serializations”.

RDF (Resource Description Framework) is a conceptual data model made up of “sentences” called triples – subjects, predicates, and objects. Subjects are expected to be URIs. Objects are expected to be URIs or string literals (think words, phrases, or numbers). Predicates are “verbs” establishing relationships between the subjects and the objects. Each triple is intended to denote a specific fact.

When the idea of the Semantic Web was first articulated XML was the predominant data structure of the time. It was seen as a way to encapsulate data that was both readable by humans as well as computers. Like any data structure, XML has both its advantages as well as disadvantages. On one hand it is easy to determine whether or not XML files are well-formed, meaning they are syntactically correct. Given a DTD, or better yet, an XML schema, it is also easy to determine whether or not an XML file is valid – meaning does it contain the necessary XML elements, attributes, and are they arranged and used in the agreed upon manner. XML also lends itself to transformations into other plain text documents through the generic, platform-independent XSLT (Extensible Stylesheet Language Transformation) process. Consequently, RDF was originally manifested – made real and “serialized” – though the use of RDF/XML.

The example of RDF at the beginning of the Guidebook was an RDF/XML serialization:

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:dcterms="http://purl.org/dc/terms/"
  xmlns:foaf="http://xmlns.com/foaf/0.1/">
  <rdf:Description rdf:about="http://en.wikipedia.org/wiki/Declaration_of_Independence">
    <dcterms:creator>
      <foaf:Person rdf:about="http://id.loc.gov/authorities/names/n79089957">
        <foaf:gender>male</foaf:gender>
      </foaf:Person>
    </dcterms:creator>
  </rdf:Description>
</rdf:RDF>
```

On the other hand, XML, almost by definition, is verbose. Element names are expected to be human-readable and meaningful, not obtuse nor opaque. The judicious use of special characters (&, <, >, “, and ‘) as well as entities only adds to the difficulty of actually reading XML. Consequently, almost from the very beginning people thought RDF/XML was not the best way to express RDF, and since then a number of other syntaxes – data structures – have manifested themselves.

Below is the same RDF serialized in a format called Notation 3 (N3), which is very human readable, but not extraordinarily structured enough for computer processing. It incorporates the use of a line-based data structure called N-Triples used to denote the triples themselves:

```
@prefix foaf: <http://xmlns.com/foaf/0.1/>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix dcterms: <http://purl.org/dc/terms/>.
<http://en.wikipedia.org/wiki/Declaration_of_Independence> dcterms:creator
<http://id.loc.gov/authorities/names/n79089957>.
<http://id.loc.gov/authorities/names/n79089957> a foaf:Person;
  foaf:gender "male".
```

JSON (JavaScript Object Notation) is a popular data structure inherent to the use of JavaScript and Web browsers, and RDF can be expressed in a JSON format as well:

```
{
  "http://en.wikipedia.org/wiki/Declaration_of_Independence": {
```

```

    "http://purl.org/dc/terms/creator": [
      {
        "type": "uri",
        "value": "http://id.loc.gov/authorities/names/n79089957"
      }
    ],
    "http://id.loc.gov/authorities/names/n79089957": {
      "http://xmlns.com/foaf/0.1/gender": [
        {
          "type": "literal",
          "value": "male"
        }
      ],
      "http://www.w3.org/1999/02/22-rdf-syntax-ns#type": [
        {
          "type": "uri",
          "value": "http://xmlns.com/foaf/0.1/Person"
        }
      ]
    }
  }
}

```

Just about the newest RDF serialization is an embellishment of JSON called JSON-LD. Compare & contrasts the serialization below to the one above:

```

{
  "@graph": [
    {
      "@id": "http://en.wikipedia.org/wiki/Declaration_of_Independence",
      "http://purl.org/dc/terms/creator": {
        "@id": "http://id.loc.gov/authorities/names/n79089957"
      }
    },
    {
      "@id": "http://id.loc.gov/authorities/names/n79089957",
      "@type": "http://xmlns.com/foaf/0.1/Person",
      "http://xmlns.com/foaf/0.1/gender": "male"
    }
  ]
}

```

RDFa represents a way of expressing RDF embedded in HTML, and here is such an expression:

```

<div xmlns="http://www.w3.org/1999/xhtml"
  prefix="
    foaf: http://xmlns.com/foaf/0.1/
    rdf: http://www.w3.org/1999/02/22-rdf-syntax-ns#
    dcterms: http://purl.org/dc/terms/
    rdfs: http://www.w3.org/2000/01/rdf-schema#"
  >
  <div typeof="rdfs:Resource" about="http://en.wikipedia.org/wiki/Declaration_of_Independence">
    <div rel="dcterms:creator">
      <div typeof="foaf:Person" about="http://id.loc.gov/authorities/names/n79089957">
        <div property="foaf:gender" content="male"></div>
      </div>
    </div>
  </div>

```

</div>
</div>

The purpose of publishing linked data is to make RDF triples easily accessible. This does not necessarily mean the transformation of EAD or MARC into RDF/XML, but rather making accessible the statements of RDF within the context of the reader. In this case, the reader may be a human or some sort of computer program. Each serialization has its own strengths and weaknesses. Ideally the archive would figure out ways exploit each of these RDF serializations in specific publishing purposes.

For a good time, play with the RDF Translator which will convert one RDF serialization into another.

The RDF serialization process also highlights how data structures are moving away from a document-centric models to a statement-central models. This too has consequences for way cultural heritage institutions, like archives, think about exposing their metadata, but that is the topic of another essay.

This is a beginner's glossary to linked data.

- * API - (see application programmer interface)

- * application programmer interface (API) - an abstracted set of functions and commands used to get output from remote computer applications. These functions and commands are not necessarily tied to any specific programming language and therefore allow programmers to use a programming language of their choice.

- * content negotiation - a process whereby a user-agent and HTTP server mutually decide what data format will be exchanged during an HTTP request. In the world of linked data, content negotiation is very important when URIs are requested by user-agents because content negotiation helps determine whether or not HTML or serialized RDF will be returned.

- * extensible markup language (XML) - a standardized data structure made up of a minimum of rules and can be easily used to represent everything from tiny bits of data to long narrative texts. XML is designed to be read by people as well as computers, but because of this it is often considered verbose, and ironically, difficult to read.

- * file transfer protocol (FTP) -

- * FTP - (see file transfer protocol)

- * HTML - (see hypertext markup language)

- * HTTP - (see hypertext transfer protocol)

- * hypertext markup language (HTML) - an XML-like data structure intended to be rendered by user-agents whose output is for people to read. For the most part, HTML is used to markup text and denote a text's stylistic characteristics such as headers, paragraphs, and list items. It is also used to markup the hypertext links (URLs) between documents.

- * hypertext transfer protocol (HTTP) - the formal name for the way the World Wide Web operates. It begins with one computer program (a user-agent) requesting content from another computer program (a server) and getting back a response. Once received, the response is formatted for reading by a person or for processing by a computer program. The shape and content of both the request and the response are what make-up the protocol.

- * Javascript object notation (JSON) - like XML, a data structure enabling allowing arbitrarily large sets of values to associated with an arbitrarily large set of names (variables). JSON was first natively implemented as a part of the Javascript language, but has since become popular in other computer languages.

- * JSON - (see Javascript object notation)

- * linked data - the stuff and technical process for making real the ideas behind the Semantic Web. It begins with the creation of serialized RDF and making the serialization available via HTTP. User agents are then expected to harvest the RDF, combine it with other harvested RDF, and ideally use it to bring to light new or existing relationships between real world objects -- people, places, and things -- thus creating and enhancing human knowledge.

- * linked open data - a qualification of linked data whereby the information being exchanged is expected to be "free" as in gratis.

- * OAI - (see Open Archives Initiative-Protocol for Metadata Harvesting)

- * ontology - a highly structured vocabulary, and in the parlance of linked data, used to denote, describe, and qualify the predicates of RDF triples. Ontologies have been defined for a very wide range of

human domains, everything from bibliography (Dublin Core or MODS), to people (FOAF), to sounds (Audio Features).

- * Open Archives Initiative-Protocol for Metadata Harvesting (OAI-PMH)

- * RDF - (see resource description framework)

- * representational state transfer (REST) - a process for querying remote HTTP servers and getting back computer-readable results. The process usually employs denoting name-value pairs in a URL and getting back something like XML or JSON.

- * resource description framework - the conceptual model for describing the knowledge of the Semantic Web. It is rooted in the notion of triples whose subjects and objects are literally linked with other triples through the use of actionable URIs.

- * REST - (see representational state transfer)

- * Semantic Web - an idea articulated by Tim Berners Lee whereby human knowledge is expressed in a computer-readable fashion and made available via HTTP so computers can harvest it and bring to light new information or knowledge.

- * serialization - a manifestation of RDF; one of any number of textual expressions of RDF triples. Examples include but are not limited to RDF/XML, RDFa, N3, and JSON-LD.

- * SPARQL - (see SPARQL protocol and RDF query language)

- * SPARQL protocol and RDF query language (SPARQL) - a formal specification for querying and returning results from RDF triple stores. It looks and operates very much like the structured query language (SQL) of relational databases complete with its SELECT, WHERE, and ORDER BY clauses.

- * triple - the atomistic facts making up RDF. Each fact is akin to a rudimentary sentence with three parts: 1) subject, 2) predicate, and 3) object. Subjects are expected to be URIs. Ideally, objects are URIs as well, but can also be literals (words, phrases, or numbers). Predicates are akin to the verbs in a sentence and they denote a relationship between the subject and object. Predicates are expected to be a member of a formalized ontology.

- * triple store - a database of RDF triples usually accessible via SPARQL

- * universal resource identifier (URI) - a unique pointer to a real-world object or a description of an object. In the parlance of linked data, URIs are expected to have the same shape and function as URLs, and if they do, then the URIs are often described as "actionable".

- * universal resource locator (URL) - an address denoting the location of something on the Internet. These addresses usually specify a protocol (like http), a host (or computer) where the protocol is implemented, and a path (directory and file) specifying where on the computer the item of interest resides.

- * URI - (see universal resource identifier)

- * URL - (see universal resource locator)

user agent - this is the formal name for what is commonly called a "Web browser", but Web browsers usually denote applications where people are viewing the results. User agents are usually "Web browsers" whose readers are computer programs.

- * XML - (see extensible markup language)

For a more complete and exhaustive glossary, see the W3C's Linked Data Glossary.

4. Linked Data Today

4.a. Projects: Brief descriptions with an emphasis on tangible benefits and outcomes of each

While the number of linked data websites is less than the worldwide total number, it is really not possible to list every linked data project but only things that will presently be useful to the archivist and computer technologist working in cultural heritage institutions. And even then the list of sites will not be complete. Instead, listed below are a number of websites of interest today.

The list is divided into three parts: introductions, data sets, and "projects". The introductions are akin to directories or initial guilds. The data sets are collections of RDF available for harvesting. The projects have used content in data sets to provide value-added information services.

Introductions

- * Datahub (<http://datahub.io/>) - This is a directory of data sets. It includes descriptions of hundreds of data collections. Some of them are linked data sets. Some of them are not.

- * LODLAM (<http://lodlam.net/>) - LODLAM is an acronym for Linked Open Data in Libraries Archives and Museums. LODLAM.net is community, both virtual and real, of linked data aficionados in cultural heritage institutions. It, like OpenGLAM, is a good place to discuss linked data in general.

- * OpenGLAM (<http://openglam.org>) - GLAM is an acronym for Galleries, Libraries, Archives, and Museums. OpenGLAM is a community fostered by the Open Knowledge Foundation and a place to discuss linked data that is "free". It, like LODLAM, is a good place to discuss linked data in general.

Data sets

- * D2R Server for the CIA Factbook (<http://wifo5-03.informatik.uni-mannheim.de/factbook/>) - The content of the World Fact Book distributed as linked data.

- * D2R Server for the Gutenberg Project (<http://wifo5-03.informatik.uni-mannheim.de/gutendata/>) - This is a data set of Project Gutenberg content -- a list of digitized public domain works, mostly books.

- * Getty Vocabularies (<http://vocab.getty.edu>) - A set of data sets used to "categorize, describe, and index cultural heritage objects and information".

- * Library of Congress Linked Data Service (<http://id.loc.gov/>) - A set of data sets used for bibliographic classification: subjects, names, genres, formats, etc.

- * Linked Archives Hub Test Dataset (<http://data.archiveshub.ac.uk>) - The data set is RDF generated from a selection of archival finding aids harvested by the Archives Hub in the United Kingdom.

- * Linked Movie Data Base (<http://linkedmdb.org/>) - A data set of movie information.

- * Linked Open Data at Europeana (<http://pro.europeana.eu/datasets>) - A growing set of RDF generated from the descriptions of content in Europeana.

- * Linked Open Vocabularies (<http://lov.okfn.org/dataset/lov/>) - A linked data set of linked data sets.

- * New York Times (<http://data.nytimes.com/>) - A list of New York Times subject headings.

- * OCLC Data Sets & Services (<http://www.oclc.org/data/>) - Here you will find a number of freely available bibliographic data sets and services. Some are available as RDF and linked data. Others are Web services.

- * PELAGIOS (<http://pelagios-project.blogspot.com/p/about-pelagios.html>) - A data set of ancient places.

* VIAF (<http://viaf.org/>) - This data set functions as a name authority file.

* Wiki.dbpedia.org (<http://dbpedia.org/About>) - In the simplest terms, this is the content of Wikipedia made accessible as RDF.

* World Bank Linked Data (<http://worldbank.270a.info/.html>) - A data set of World Bank indicators, climate change information, finances, etc.

Projects

* 20th Century Press Archives (<http://zbw.eu/beta/p20>) - "I've (Neubert Joachim <J.Neubert@zbw.eu>) published the persons and company part of the 20th Century Press Archives (<http://zbw.eu/beta/p20>) as a linked data application. It uses RDFa and OAI-ORE extensively to give every dossier, every article and every page a citable URI, and on the other hand consumes linked data from various linked data sources to enrich the web pages and to provide context to the rather plain scanned article images. See http://challenge.semanticweb.org/submissions/swc2010_submission_6.pdf for more detail."

* Linking Lives (<http://archiveshub.ac.uk/linkinglives/>) - Linking Lives is exploring ways to present Linked Data. We aim to show that archives can benefit from being presented as a part of the diverse data sources on the Web to create full biographical pictures, enabling researchers to make connections between people and events. Linking Lives builds upon the Locah project. Locah was a JISC-funded project to expose the Archives Hub descriptions as Linked Data.

* LOCAH Project (<http://archiveshub.ac.uk/locah/>) - Mimas and UKOLN worked together on an exciting JISC funded project to make Archives Hub data available as structured Linked Data, for the benefit of education and research. We worked in partnership with Eduserv, Talis and OCLC, leading experts within their fields. The aim was put archival and bibliographic data at the heart of the Linked Data Web, enabling new links to be made between diverse content sources and enabling the free and flexible exploration of data so that researchers can make new connections between subjects, people, organisations and places to reveal more about our history and society.

* OpenCat (<http://demo.cubicweb.org/opencatfresnes/>) - Another common theme / application demonstrated at the conference were variations of the venerable library catalog. OpenCat, presented by Agnes Simon (Bibliothèque Nationale de France), was an additional example of this trend. Combining authority data (available as RDF) provided by the National Library of France with works of a second library (Fresnes Public Library), the OpenCat prototype provides quite an interesting interface to library holdings.

* Reload (<http://labs.regesta.com/progettoReload/en>) - an Italian experimentation started in 2012 and supported by Central State Archive, Cultural Heritage Institute of Emilia Romagna Region and regesta.exe, published the first version of OAD ontology (ontology for archival description) based on ISAD (G) standard and EAD schema, in 2013. The project team define a specific ontology for archival description domain because there isn't yet something useful to describe all significant classes and properties necessary in archival description and we integrated OAD with other "Lightweight ontologies" (like foaf or dublin core) to encode the most common metadata. Within Reload project, to describe authority records in Linked Data we use EAC-CPF ontology, published in 2012 by Cultural Heritage Institute of Emilia Romagna Region. From the website: "The Reload project (Repository for Linked open archival data) will foster experimentation with the technology and methods of linked open data for archival resources. Its goal is the creation of a web of linked archival data."

4.b. Trends in LOD-LAM

- * Mash ups
- * Harvesting along side other protocols
- * Increased interest
- * Increased number of RDF serializations
- * Governments making their content available
- * Using them to enhance online catalogs
- * Creating timelines
- * Creating “named graphs”
- * Increased number of programming toolkits
- * Emphasis on “open” linked data and linked data in museums and archives
- * Making RDF dumps available
- * Interest in schema.org

With great interest I read the Spring/Summer issue of Information Standards Quarterly where there were a number of articles pertaining to linked open data in cultural heritage institutions. [0] Of particular interest to me where the various loosely enumerated challenges of linked open data. Some of them included:

- * the apparent Tower Of Babel when it comes to vocabularies used to describe content, and the same time we need to have “ontology mindfulness”.
- * dirty, inconsistent, or wide varieties of data integrity
- * persistent URIs
- * the “chicken & egg” problem of why linked data if there is no killer application

5. Getting Started: Strategies and Steps

Linked data represents a modern way of making your archival descriptions accessible to the wider world. In that light, it represents a different way of doing things but not necessary a different what of doing things. You will still be doing inventory. You will still be curating collections. You will still be prioritizing what goes and what stays.

On the other hand, linked data changes the way your descriptions get expressed and distributed. It is a lot like taking a trip across country. The goal was always to get to the coast to see the ocean, but instead of walking, going by stage coach, taking a train, or driving a car, you will be flying. Along the way you may visit a few cities and have a few layovers. Bad weather may even get in the way, but sooner or later you will get to your destination. Take a deep breath. Understand that the process will be one of learning, and that learning will be applicable in other aspects of your work. The result will be two-fold. First, a greater number of people will have access to your collections, and consequently, more people will be using your collections.

5.a. Defining your strategy: Articulate goals, objectives, and metrics to measure success.

With this in mind, articulate some goals – broad targets of things you would like to accomplish. Some of them might include:

- * making your archival collections more widely accessible
- * working with others to build virtual collections of like topics or formats
- * incorporating your archival descriptions into public spaces like Wikipedia
- * integrating your collections into local teaching, learning, and research activities
- * increasing the awareness of your archive to benefactors
- * increasing the computer technology skills of fellow archivists

How might you go about accomplishing these goals? What are your objectives? (What method of transportation are you going to use to get where you are going?) How am I going to measure success? In other words, you will need to create a plan, and each item in the plan answers a simple question – Who is going to do what by when? In other word, what people will be responsible for accomplishing the particular objective. Exactly what will they be doing, and by what time will they have it accomplished. Each of these components are described in greater detail below

Who

It is quite unlikely your linked data goals and objectives will be accomplished by a single person. Instead it will most likely required a team of people. These people do not necessarily need to working in the same physical location, but they will require a diverse set of skills. Some of them include, and each plays a key, indispensable role:

- * content specialists - These are the people who understand the “aboutness” of a particular collection. These are the people who understand and can thoroughly articulate the significance of a collection. They know how and why particular things belong in a collection. They are able to answer questions about the collection as all as tell stories against it.

- * metadata specialists - These are people who understand data about data. Not only do they understand the principles of controlled vocabularies and authority lists, but they are also familiar with a wide variety of such lists, specifically as they are represented on the Web. In linked data there are fewer descriptive cataloging “rules”. Nevertheless, the way the ontologies of linked data can be used need to be interpreted, and this interpretation needs to be consistent. Metadata specialists understand these principles.

- * computer technologists - Not only are these the people who have a fundamental understanding of what computer can and cannot do, but they also know how to put this understanding into practice. At the very least, the computer technologists need to understand a myriad of data structures and how to convert them into different data structures. Converting MARC 21 into MARCXML. Transforming EAD into HTML. Reporting against a relational database to create serialized RDF. These tasks required computer programming skills, but not necessarily any one in particular. Any modern programming language (Java, PHP, Python, Ruby, etc.) includes the necessary function to complete the tasks.

What

The what of your objectives are not so much identified with nouns as they are action verbs, such as: write, evaluate, implement, examine, purchase, hire, prioritize, list, delete, acquire, discuss, share, find, compare & contrast, stop, start, complete, continue, describe, edit, updated, create, purchase, upgrade, etc. The what of your objective is in the doing.

When

The say, “Work expands to fill the available space.” If this is true, and no deadlines are articulated for

each objective, then the allotted amount of time for any given task is all but infinite, but this it not true. Time is one of the most limited resources you have. When thinking about a given objective, ask yourself how much time you think it will take, multiply the time by one and a half. Ask yourself when the task can begin and document the beginning point as well as the estimated ending point. Do this all of your objectives and the result will be a Gantt chart. It will now be easy to look at the chart on a regular basis to see who things are progressing.

2.a Lots of ways to participate

- * finding URIs
- * associating URIs with predicates
- * publishing serialized RDF with: 1) pure HTTP, and/or 2) SPARQL
- * harvesting RDF
- * storing RDF
- * analyzing RDF
- * providing services against RDF
- * leading groups of people
- * articulating policies
- * allocating resources

5.a Linked data and archival practice: Or, There is more than one way to get there

Two recent experiences have taught me that – when creating some sort of information service – linked data will reside and be mixed in with data collected from any number of Internet techniques. Linked data interfaces will coexist with REST-ful interfaces, or even things as rudimentary as FTP. To the archivist, this means linked data is not the be-all and end-all of information publishing. There is no such thing. To the application programmer, this means you will need to have experience with a ever-growing number of Internet protocols. To both it means, “There is more than one way to get there.”

In October of 2013 I had the opportunity to attend the Semantic Web In Libraries conference. It was a three-day event attended by approximately three hundred people who could roughly be divided into two equally sized groups: computer scientists and cultural heritage institution employees. The bulk of the presentations fell into two categories: 1) publishing linked data, and 2) creating information services. The publishers talked about ontologies, human-computer interfaces for data creation/maintenance, and systems exposing RDF to the wider world. The people creating information services were invariably collecting, homogenizing, and adding value to data gathered from a diverse set of information services. These information services were not limited to sets of linked data. They also included services accessible via REST-ful computing techniques, OAI-PMH interfaces, and there were probably a few locally developed file transfers or relational database dumps described as well. These people were creating lists of information services, regularly harvesting content from the services, writing cross-walks, locally storing the content, indexing it, providing services against the result, and sometimes republishing any number of “stories” based on the data. For the second group of people, linked data was certainly not the only game in town.

In February of 2014 I had the opportunity to attend a hackathon called GLAM Hack Philly. A wide variety of data sets were presented for “hacking” against. Some were TEI files describing Icelandic manuscripts. Some was linked data published from the British museum. Some was XML describing digitized journals created by a vendor-based application. Some of it resided in proprietary database applications describing the location of houses in Philadelphia. Some of it had little or no computer-readable structure at all and described plants. Some of it was the wiki mark-up for local municipalities. After the attendees (there were about two dozen of us) learned about each of the data sets we self-selected and hacked away at projects of our own design. The results fell into roughly three categories: geo-referencing objects, creating searchable/browsable interfaces, and data enhancement. With the exception of the resulting hack repurposing journal content to create new art, the results were pretty typical for cultural heritage institutions. But what fascinated me was way us hackers selected our data sets. Namely, the more complete and well-structured the data was the more hackers gravitated towards it. Of all the data sets, the TEI files were the most complete, accurate, and computer-readable. Three or four projects were done against the TEI. (Heck, I even hacked on the TEI files.) The linked data from the British Museum – very well structured but not quite as thorough as the TEI – attracted a large number of hackers who worked together for a common goal. All the other data sets had only one or two people working on them. What is the moral to the story? There are two of them. First, archivists, if you want people to process your data and do “kewl” things against it, then make sure the data is thorough, complete, and computer-readable. Second, computer programmers, you will need to know a variety of data formats. Linked data is not the only game in town.

In summary, the technologies described in this Guidebook are not the only way to accomplish the goals of archivists wishing to make their content more accessible. Instead, linked data is just one of many protocols in the toolbox. It is open, standards-based, and simpler rather than more complex. On the other hand, other protocols exist which have a different set of strengths and weaknesses. Computer technologists will need to have a larger rather than smaller knowledge of various Internet tools. For archivists, the core of the problem is still the collection and description of content. This – a what of archival practice – continues to remain constant. It is the how of archival practice – the technology – that changes at a much faster pace.

5.b. Is your archival description LOD-ready?

Is your archival description LOD-ready? Now? The simple, straight-forward answer is, "Yes." The longer and more complicated answer is, "No. Your data is never 100% linked data ready because the process of archival description is never finished." That said, the balance of the Guide describes what you can do going forward.

5.c. Identify building blocks: metadata components in archival description that are (or nearly are) ready for linking.

5.d. Readiness: Making small changes in practice to make your description LOD-ready.

5.e. What you can do now if you have:

5.e.i. EAD

If you have used EAD to describe your collections, then you can easily make your descriptions available as valid linked data, but the result will be less than optimal. This is true not for a lack of technology but rather from the inherent purpose and structure of EAD files.

A few years ago an organisation in the United Kingdom called the Archive's Hub was funded by a granting agency called JISC to explore the publishing of archival descriptions as linked data. One of the outcomes of this effort was the creation of an XSL stylesheet transforming EAD into RDF/XML. The terms used in the stylesheet originate from quite a number of standardized, widely accepted ontologies, and with only the tiniest bit configuration / customization the stylesheet can transform a generic EAD file into valid RDF/XML. The resulting XML files can then be made available on a Web server or incorporated into a triple store. This goes a long way to publishing archival descriptions as linked data. The only additional things needed are a transformation of EAD into HTML and the configuration of a Web server to do content-negotiation between the XML and HTML.

For the smaller archive with only a few hundred EAD files whose content does not change very quickly, this is a simple, feasible, and practical solution to publishing archival descriptions as linked data. With the exception of doing some content-negotiation, this solution does not require any computer technology that is not already being used in archives, and it only requires a few small tweaks to a given workflow:

- * implement a content-negotiation solution
- * edit EAD file
- * transform EAD into RDF/XML
- * transform EAD into HTML
- * save the resulting XML and HTML files on a Web server
- * go to step #2

On the other hand an EAD file is the combination of a narrative description with a hierarchal inventory list, and this data structure does not lend itself very well to the triples of linked data. For example, EAD headers are full of controlled vocabularies terms but there is no way to link these terms with specific inventory items. This is because the vocabulary terms are expected to describe the collection as a whole, not individual things. This problem could be overcome if each individual component of the EAD were associated with controlled vocabulary terms, but this would significantly increase the amount of work needed to create the EAD files in the first place.

The common practice of using literals ("strings") to denote the names of people, places, and things in EAD files would also need to be changed in order to fully realize the vision of linked data. Specifically, it would be necessary for archivists to supplement their EAD files with commonly used URIs denoting subject headings and named authorities. These URIs could be inserted into id attributes throughout an EAD file, and the resulting RDF would be more linkable, but the labor to do so would increase, especially since many of the named authorities will not exist in standardized authority lists.

Despite these shortcomings, transforming EAD files into some sort of serialized RDF goes a long way towards publishing archival descriptions as linked data. This particular process is a good beginning and outputs valid information, just information that is not as accurate as possible. This process lends itself to iterative improvements, and outputting something is better than outputting nothing. But this particular process is not for everybody. The archive whose content changes quickly, the archive with copious numbers of collections, or the archive wishing to publish the most accurate linked data possible will probably not want to use EAD files as the root of their publishing system. Instead some sort of database application is probably the best solution.

5.e.ii. EAC-CPF

Encoded Archival Context for Corporate Bodies, Persons, and Families (EAC-CPF) goes a long way to implementing a named authority database that could be linked from archival descriptions. These XML files could easily be transformed into serialized RDF and therefore linked data. The resulting URIs could then be incorporated into archival descriptions making them richer and complete.

For example the FindAndConnect site in Australia uses EAC-CPF under the hood to disseminate information about people in its collection -- <http://www.findandconnect.gov.au>. Similarly, “SNAC aims to not only make the [EAC-CPF] records more easily discovered and accessed but also, and at the same time, build an unprecedented resource that provides access to the socio-historical contexts (which includes people, families, and corporate bodies) in which the records were created” -- <http://socialarchive.iath.virginia.edu> More than a thousand EAC-CPF records are available from the RAMP project -- <http://demo.rampeditor.info/export.php>

5.e.iii. MARC

In some ways MARC lends it self very well to being published via linked data, but in the long run it is not really a feasible data structure.

Converting MARC into serialized RDF through XSLT is at least a two step process. The first step is to convert MARC into MARCXML. This can be done with any number of scripting languages and toolboxes. The second step is to use a stylesheet such as the one provided by the Library of Congress to transform the MARCXML into RDF/XML. From there a person could save the resulting XML files on a Web server, enhance access via content negotiation, and called it linked data.

Unfortunately, this particular approach has a number of drawbacks. First and foremost, the MARC format had no place to denote URIs; MARC records are made up almost entirely of literals. Sure, URIs can be constructed from various control numbers, but things like authors, titles, subject headings, and added entries will most certainly be strings (“Mark Twain”, “Adventures of Huckleberry Finn”, “Bildungsroman”, or “Samuel Clemans”), not URIs. This issue can be overcome if the MARCXML were first converted into MODS and URIs were inserted into id or xlink attributes of bibliographic elements, but this is extra work. If an archive were to take this approach, then it would also behoove them to use MODS as their data structure of choice, not MARC. Continually converting from MARC to MARCXML to MODS would be expensive in terms of time. Moreover, with each new conversion the URIs from previous iterations would need to be re-created.

5.e.iv. METS, MODS, and perhaps more.

If you have archival descriptions in either of the METS or MODS formats, then transforming them into RDF is as far away as your XSLT processor and a content negotiation implementation. As of this writing there do not seem to be any METS to RDF stylesheets, but there are a couple stylesheets for MODS. The biggest issue with these sorts of implementations are the URIs. It will be necessary for archivists to include URIs into as many MODS id or xlink attributes as possible. The same thing holds true for METS files except the id attribute is not designed to hold external

5.e.v. Databases

Publishing linked data through XML transformation is functional but not optimal. Publishing linked data from a database comes closer to the ideal but requires a greater amount of technical computer infrastructure and expertise.

Databases -- specifically, relational databases -- are the current best practice for organizing data. As you may or may not know, relational databases are made up of many tables of data joined with keys. For example, a book may be assigned a unique identifier. The book has many characteristics such as a title, number of pages, size, descriptive note, etc. Some of the characteristics are shared by other books, like authors and subjects. In a relational database these shared characteristics would be saved in additional tables, and they would be joined to a specific book through the use of unique identifiers (keys). Given this sort of data structure, reports can be created from the database describing its content. Similarly, queries can be applied against the database to uncover relationships that may not be apparent at first glance or buried in reports. The power of relational databases lay in the use of keys to make relationships between rows in one table and rows in other tables.

Not coincidentally, this is very much the way linked data is expected to be implemented. In the linked data world, the subjects of triples are URIs (think database keys). Each URI is associated with one or more predicates (think the characteristics in the book example). Each triple then has an object, and these objects take the form of literals or other URIs. In the book example, the object could be “Adventures Of Huckleberry Finn” or a URI pointing to Mark Twain. The reports of relational databases are analogous to RDF serializations, and SQL (the relational database query language) is analogous to SPARQL, the query language of RDF triple stores. Because of the close similarity between well-designed relational databases and linked data principles, the publishing of linked data directly from relational databases makes whole lot of sense, but the process requires the combined time and skills of a number of different people: content specialists, database designers, and computer programmers. Consequently, the process of publishing linked data from relational databases may be optimal, but it is more expensive.

Thankfully, most archivists probably use some sort of database to manage their collections and create their finding aids. Moreover, archivists probably use one of three or four tools for this purpose: Archivist’s Toolkit, Archon, ArchivesSpace, or PastPerfect. Each of these systems have a relational database at their heart. Reports could be written against the underlying databases to generate serialized RDF and thus begin the process of publishing linked data. Doing this from scratch would be difficult, as well as inefficient because many people would be starting out with the same database structure but creating a multitude of varying outputs. Consequently, there are two alternatives. The first is to use a generic database application to RDF publishing platform called D2RQ. The second is for the community to join together and create a holistic RDF publishing system based on the database(s) used in archives.

D2RQ is a wonderful software system. It is supported, well-documented, executable on just about any computing platform, open source, focused, functional, and at the same time does not try to be all things to all people. Using D2RQ it is more than possible to quickly and easily publish a well-designed relational database as RDF. The process is relatively simple:

- * download the software
- * use a command-line utility to map the database structure to a configuration file
- * season the configuration file to taste
- * run the D2RQ server using the configuration file as input thus allowing people or RDF user-agents to search and browse the database using linked data principles
- * alternatively, dump the contents of the database to an RDF serialization and upload the result into your favorite RDF triple store

The downside of D2RQ is its generic nature. It will create an RDF ontology whose terms correspond to the names of database fields. These field names do not map to widely accepted ontologies and therefore will not interact well with communities outside the ones using a specific database structure. Still, the use of D2RQ is quick, easy, and accurate.

The second alternative to using databases of archival content to published linked data requires community effort and coordination. The databases of Archivist's Toolkit, Archon, ArchivesSpace, or Past Perfect could be assumed. The community could then get together and create and decide on an RDF ontology to use for archival descriptions. The database structure(s) could then be mapped to this ontology. Next, programs could be written against the database(s) to create serialized RDF thus beginning the process of publishing linked data. Once that was complete, the archival community would need to come together again to ensure it uses as many shared URIs as possible thus creating the most functional sets of linked data. This second alternative requires a significant amount of community involvement and wide-spread education. It represents a never-ending process.

6. On Your Way: Next Steps

6.a. Integration into daily practice

6.b. Three Cs: Cleanup, Conversion, Consistency

The article entitled Recipes for Enhancing Digital Collections with Linked Data by Thomas Johnson and Karen Estlund (<http://journal.code4lib.org/articles/9214>) outlines a number of ways of cleaning up data in content management systems by way of RDF statements.

clean up steps include:

1. Remove noise
2. Normalize presentation
3. Assign URIs for curation objects
4. Map legacy elements to Linked Data vocabularies

As stated by Hillman, the process of moving to linked data is The key to this augmentation process involves changing the basic metadata unit from “record” to “statement.” – <http://dcpapers.dublincore.org/pubs/article/view/770/766>

Problems with data, again from hillman an:

1. missing data – metadata elements not present in supplied metadata
2. incorrect data – metadata values not conforming to standard element use
3. confusing data – multiple values crammed into a single metadata element, embedded html tags, etc.
4. insufficient data – e.g., no indication of controlled vocabularies used

Safe transformations include:

1. remove “noise” – a partial solution to the “incorrect data” problem. For example, we remove metadata with no information value, such as empty metadata elements, metadata elements with values such as “unknown” or “n/a” or consisting entirely of dashes or other punctuation.
2. detect and identify controlled vocabularies in use whenever possible – a partial solution to the “insufficient data” problem. For example, the DCMITypes encoding scheme is applied to DC “Type” elements when their value is one of the allowed DCMITypes [10]. This works well for small controlled vocabularies; however, it does not scale well to large vocabularies such as LCSH.
3. normalize metadata presentation – clean up the values: remove double XML encodings (“<” becomes “<”), extra whitespace (a tab followed by five spaces becomes a single space), etc.

Creating and maintaining metadata is a never-ending process. The items being described can always use elaboration. Collections may increase in size. Rights applied against content may change. Things become digitized, or digitized things are migrated from one format to another. Because of these sorts of things and many others, cleanup, conversion, and consistency are something every metadata specialist needs to keep in mind.

Cleanup, conversion, and consistency means many things. Does all of your metadata use the same set of one or more vocabularies? Are things spelled correctly? Maybe you used abbreviations in one document but spelled things out in another? Have you migrated your JPEG images to JPEG2000 or TIFF formats? Maybe the EAD DTD has been updated, and you want (need) to migrate your finding aids from one XML format to another? Do all of your finding aids exhibit the same level of detail; are some “thinner” than others? Have you used one form of a person’s name in one document but used another form in a different document? The answers to these sorts of questions point to the need for cleanup, conversion, and consistency.

6.c. Tools

* Fusion Tables (<http://www.google.com/drive/apps.html>) - Bust your data out of its silo! Combine it with other data on the web. Collaborate, visualize and share.

* OpenRefine (<https://github.com/OpenRefine/>) - OpenRefine is a free, open source power tool for working with messy data and improving it

* cURL - `curl -L -H 'Accept: application/rdf+xml' http://infomotions.com/sandbox/liam/id/ctumarc15567`

7. Looking Ahead: Advanced Tools and Visualizations

7.a. Tools for archivists (data preparation, cleanup, management)

- * 4store - Scalable RDF Storage (<http://4store.org/>) -

- * Apache Jena - Home (<http://jena.apache.org/>) -

- * Behas/oai2lod (<https://github.com/behas/oai2lod>) -

- * Bibframe (<http://bibframe.org>) - The Bibliographic Framework Initiative (BIBFRAME) is an undertaking by the Library of Congress and the community to better accommodate future needs of the library community. A major focus of the initiative will be to determine a transition path for the MARC 21 exchange format to more Web based, Linked Data standards. Zepheira and The Library of Congress are working together to develop a Linked Data model, vocabulary and enabling tools / services for supporting this Initiative.

- * BIBFRAME.ORG (<http://bibframe.org/>) -

- * ckan (<http://ckan.org>) - The open source data portal software

- * Ckan (<http://ckan.org/>) -

- * ConverterToRdf (<http://www.w3.org/wiki/ConverterToRdf>) -

- * CouchDB (<http://couchdb.apache.org>) - CouchDB is a database that completely embraces the web. Store your data with JSON documents. Access your documents with your web browser, via HTTP. Query, combine, and transform your documents with JavaScript. CouchDB works well with modern web and mobile apps. You can even serve web apps directly out of CouchDB. And you can distribute your data, or your apps, efficiently using CouchDB's incremental replication. CouchDB supports master-master setups with automatic conflict detection.

- * Curl (<http://curl.haxx.se>) - curl is a command line tool for transferring data with URL syntax, supporting DICT, FILE, FTP, FTPS, Gopher, HTTP, HTTPS, IMAP, IMAPS, LDAP, LDAPS, POP3, POP3S, RTMP, RTSP, SCP, SFTP, SMTP, SMTPS, Telnet and TFTP. curl supports SSL certificates, HTTP POST, HTTP PUT, FTP uploading, HTTP form based upload, proxies, cookies, user+password authentication (Basic, Digest, NTLM, Negotiate, kerberos...), file transfer resume, proxy tunneling and a busload of other useful tricks.

- * Curl and Libcurl (<http://curl.haxx.se/>) -

- * D2R Server (<http://d2rq.org/d2r-server>) -

- * D2RQ (<http://d2rq.org>) - The D2RQ Platform is a system for accessing relational databases as virtual, read-only RDF graphs. It offers RDF-based access to the content of relational databases without having to replicate it into an RDF store. Using D2RQ you can: query a non-RDF database using SPARQL, access the content of the database as Linked Data over the Web, create custom dumps of the database in RDF formats for loading into an RDF store, access information in a non-RDF database using the Apache Jena API

- * D2RQ Platform (<http://d2rq.org/>) -

- * D3.js (<http://d3js.org>) - D3.js is a JavaScript library for manipulating documents based on data. D3 helps you bring data to life using HTML, SVG and CSS. D3's emphasis on web standards gives you the full capabilities of modern browsers without tying yourself to a proprietary framework, combining powerful visualization components and a data-driven approach to DOM manipulation.

- * Datahub (<http://datahub.io/>) - the free, powerful data management platform from the Open Knowledge Foundation

- * Disco - Hyperdata Browser (<http://wifo5-03.informatik.uni-mannheim.de/bizer/ng4j/disco/>) - The Disco - Hyperdata Browser is a simple browser for navigating the Semantic Web as an unbound set of data sources.

The browser renders all information, that it can find on the Semantic Web about a specific resource, as an HTML page. This resource description contains hyperlinks that allow you to navigate between resources. While you move from resource to resource, the browser dynamically retrieves information by dereferencing HTTP URIs and by following `rdfs:seeAlso` links.

- * Disco Hyperdata Browser (<http://wifo5-03.informatik.uni-mannheim.de/bizer/ng4j/disco/>) -
- * Ead2rdf (<http://data.archiveshub.ac.uk/xslt/ead2rdf.xsl>) -
- * ead2rdf (<http://data.archiveshub.ac.uk/xslt/ead2rdf.xsl>) - The “transform” process is currently performed using XSLT to read an EAD XML document and output RDF/XML, and the current version of the stylesheet is now available:
- * eaditor (<https://github.com/ewg118/eaditor>) - EADitor is an XForms framework for the creation and editing of Encoded Archival Description (EAD) finding aids using Orbeon, an enterprise-level XForms Java application, which runs in Apache Tomcat.
- * Ewg118/eaditor (<https://github.com/ewg118/eaditor>) -
- * Fusion Tables (<http://www.google.com/drive/apps.html>) - Bust your data out of its silo! Combine it with other data on the web. Collaborate, visualize and share.
- * Gephi (<http://gephi.org>) - Gephi is an interactive visualization and exploration platform for all kinds of networks and complex systems, dynamic and hierarchical graphs.
- * Google Drive (<http://www.google.com/drive/apps.html>) -
- * Library, The standard EAC-CPF is maintained by the Society of American Archivists in partnership with the Berlin State. “Society of American Archivists and the Berlin State Library (<http://eac.staatsbibliothek-berlin.de/>) -
- * Linked Data Tools (<http://linkeddata.org/tools>) -
- * Linked Media Framework (<https://code.google.com/p/lmf/>) -
- * Linked Media Framework (<https://code.google.com/p/lmf/>) - The Linked Media Framework is an easy-to-setup server application that bundles together some key open source projects to offer some advanced services for linked media management.
- * oai2lod (<https://github.com/behaoai2lod>) - exposes OAI-PMH data sources as Linked Data
- * OpenLink Data Explorer Extension (<http://ode.openlinksw.com>) - The OpenLink Data Explorer (ODE) is a browser extension (currently available for Firefox, Safari, Chrome, Opera, and Internet Explorer with additional browser support to follow) that adds a new option to the realm of Web User Agent functionality, in the form of new menu options for viewing Data Sources associated with Web Pages.
- * OpenLink Data Explorer Extension (<http://ode.openlinksw.com/>) -
- * openRDF.org (<http://www.openrdf.org/>) -
- * OpenRefine (<https://github.com/OpenRefine/>) -
- * OpenRefine (<https://github.com/OpenRefine/>) - OpenRefine is a free, open source power tool for working with messy data and improving it
- * Parrot, a RIF and OWL Documentation Service.” Accessed November 11, 2013.
<http://ontorule-project.eu/parrot/parrot>) -

* Perl and RDF (<http://www.perlrdf.org>) - The Perl RDF project hopes to address these issues:, publish an official API for storage, parsing and serializing modules, produce a set of base classes for representing common RDF objects such as statements and nodes (resources, literals, blank nodes), produce patches to existing RDF tools to support these APIs, subclassing where appropriate, produce a test suite for storage, parsing, serializing, statement and node classes.

* Perl-SPARQL-client-library (<https://github.com/swh/Perl-SPARQL-client-library>) - A simple Perl library for accessing SPARQL endpoints.

* Protégé (<http://protege.stanford.edu>) - Protégé is a free, open source ontology editor and knowledge-base framework The Protégé platform supports modeling ontologies via a web client or a desktop client. Protégé ontologies can be developed in a variety of formats including OWL, RDF(S), and XML Schema Protégé is based on Java, is extensible, and provides a plug-and-play environment that makes it a flexible base for rapid prototyping and application development.

* Protégé Ontology Editor (<http://protege.stanford.edu/>) -

* RDF2RDF (<http://www.l3s.de/~minack/rdf2rdf/>) -

* RDFImportersAndAdapters (<http://www.w3.org/wiki/RDFImportersAndAdapters>) - Tools and applications that can convert from other data and file formats to RDF.

* RDFImportersAndAdapters (<http://www.w3.org/wiki/RDFImportersAndAdapters>) -

* RDFizers - SIMILE (<http://simile.mit.edu/wiki/RDFizers>) -

* Semantic Web Client Library (<http://wifo5-03.informatik.uni-mannheim.de/bizer/ng4j/semwebclient/>) -

* Semantic Web Development Tools (<http://www.w3.org/2001/sw/wiki/Tools>) - This Wiki contains a collection of tool references that can help in developing Semantic Web applications. These include complete development environments, editors, libraries or modules for various programming languages, specialized browsers, etc. The goal is to list such tools and not Semantic Web applications in general (the interested reader may consider looking at the W3C SW Use Case Collection for those.)

* Sematic Web Client Library (<http://wifo5-03.informatik.uni-mannheim.de/bizer/ng4j/semwebclient/>) - The Sematic Web Client Library represents the complete Semantic Web as a single RDF graph. The library enables applications to query this global graph using SPARQL- and find(SPO) queries. To answer queries, the library dynamically retrieves information from the Semantic Web by dereferencing HTTP URIs, by following rdfs:seeAlso links, and by querying the Sindice search engine. The library is written in Java and is based on the Jena framework.

* SemWebClients (<http://www.w3.org/wiki/TaskForces/CommunityProjects/LinkingOpenData/SemWebClients>) -

* SIMILE Widgets | Exhibit (<http://www.simile-widgets.org/exhibit/>) -

* SparqlImplementations (<http://www.w3.org/wiki/SparqlImplementations>) -

* SparqlImplementations (<http://www.w3.org/wiki/SparqlImplementations>) - This page lists some implementations of SPARQL, a query language and protocol for RDF access released by the W3C RDF Data Access Working Group - DAWG.

* swh/Perl-SPARQL-client-library (<https://github.com/swh/Perl-SPARQL-client-library>) -

* Tableau Public (<http://www.tableausoftware.com/public>) - With Tableau Public you can create interactive graphs, dashboards, maps and tables from virtually any data and embed them on your website or blog in minutes.

* Tableau Public (<http://www.tableausoftware.com/public>) - With Tableau Public you can create interactive graphs, dashboards, maps and tables from virtually any data and embed them on your website or blog in minutes.

* Tableau Public (<http://www.tableausoftware.com/public/community>) -

* Tabulator (<http://www.w3.org/2005/ajar/tab>) -

* Tabulator (<http://www.w3.org/2005/ajar/tab>) - The Tabulator project is a generic data browser and editor. Using outline and table modes, it provides a way to browse RDF data on the web. RDF is the standard for inter-application data exchange.

* TemaTres (<http://www.vocabularyserver.com>) - The open source way to manage formal representations of knowledge

* TemaTres (<http://www.vocabularyserver.com/>) -

* Tools (<http://linkeddata.org/tools>) -

* Tools (<http://www.w3.org/2001/sw/wiki/Tools>) -

* Vapour, a Linked Data Validator (<http://validator.linkeddata.org/vapour>) -

* VirtuosoUniversalServer (<http://www.w3.org/wiki/VirtuosoUniversalServer>) -

* VirtuosoUniversalServer (<http://www.w3.org/wiki/VirtuosoUniversalServer>) - OpenLink Virtuoso is a multi-purpose and multi-protocol (Hybrid) Data Server from OpenLink Software that includes SQL Object-Relational, RDF, XML, and Free Text data management, alongside Web Application (HTTP, SOAP, WebDAV), SyncML, and Discussion Server functionality, in a single server.

* W3C RDF Validation Service (<http://www.w3.org/RDF/Validator/>) -

* W3C RDF Validation Service (<http://www.w3.org/RDF/Validator/>) - Enter a URI or paste an RDF/XML document into the text field above. A 3-tuple (triple) representation of the corresponding data model as well as an optional graphical visualization of the data model will be displayed.

* W3c/rdfvalidator-ng (<https://github.com/w3c/rdfvalidator-ng>) -

* Working with RDF with Perl (<http://www.perlrdf.org/>)

7.b. Tools for users (visualizations, interfaces)

7.a.ii. Gaps: What is needed

There needs to be easy to use tools to find URIs and insert them in to archival descriptions. One such tool is called lobid:

In “From strings to things: A linked data API for library hackers and Web developers” Fabian Steeg and Pascal Christoph (HBZ) described an interface allowing librarians to determine the URIs of people, places, and things for library catalog records. “How can we benefit from linked data without being linked data experts? We want to put Web developers into focus using JSON for HTTP.” There are few hacks illustrating some of their work on Github in the lobid repository. --<https://github.com/lobid>

Another example would be an interface to the various linked data sets available from the Library of Congress. --<http://id.loc.gov>

Listed in no priority order, some of the things needed, include:

- * hands-on training
- * desktop tools enabling people or machines to associate strings with URIs
- * a simple RDF statement editor
- * the killer app / additional demonstration applications
- * a conceptual shift from document to statement

8.3 Further reading

This is a list of links and citations to get one started on Linked Open Data

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Appendix A: cURL and content-negotiation

This is the tiniest introduction to cURL and content-negotiation. cURL is a command-line tool making it easier for you to see the Web as data and not presentation. It is a sort of Web browser, but more specifically, it is a thing called a user-agent. Content-negotiation is an essential technique for publishing and making accessible linked data. Please don't be afraid of the command-line though. Understanding how to use cURL and do content-negotiation by hand will take you a long way in understanding linked data.

The first step is to download and install cURL. If you have a Macintosh or a Linux computer, then it is probably already installed. If not, then give the cURL download wizard a whirl. We'll wait.

Next, you need to open a terminal. On Macintosh computers a terminal application is located in the Utilities folder of your Applications folder. It is called "Terminal". People using Windows-based computers can find the "Command" application by searching for it in the Start Menu. Once cURL has been installed and a terminal has been opened, then you can type the following command at the prompt to display a help text:

```
curl --help
```

There are many options there, almost too many. It is often useful to view only one page of text at a time, and you can "pipe" the output through to a program called "more" to do this. By pressing the space bar, you can go forward in the display. By pressing "b" you can go backwards, and by pressing "q" you can quit:

```
curl --help | more
```

Feed cURL the complete URL of Google's home page to see how much content actually goes into their "simple" presentation:

```
curl http://www.google.com/ | more
```

The communication of the World Wide Web (the hypertext transfer protocol or HTTP) is divided into two parts: 1) a header, and 2) a body. By default cURL displays the body content. To see the header, add the -I (for a mnemonic, think "information") to the command:

```
curl -I http://www.google.com/
```

The result will be a list of characteristics the remote Web server is using to describe this particular interaction between itself and you. The most important things to note are: 1) the status line and 2) the content type. The status line will be the first line in the result, and it will say something like "HTTP/1.1 200 OK", meaning there were no errors. Another line will begin with "Content-Type:" and denotes the format of the data being transferred. In most cases the content type line will include something like "text/html" meaning the content being sent is in the form of an HTML document.

Now feed cURL a URI for Walt Disney, such as one from DBpedia:

```
curl http://dbpedia.org/resource/Walt_Disney
```

The result will be empty, but upon the use of the -I switch you can see how the status line changed to "HTTP/1.1 303 See Other". This means there is no content at the given URI, and the line starting with "Location:" is a pointer – an instruction – to go to a different document. In the parlance of HTTP this is called redirection. Using cURL going to the recommended location results in a stream of HTML:

```
curl http://dbpedia.org/page/Walt_Disney | more
```

Most Web browsers automatically follow HTTP redirection commands, but cURL needs to be told this explicitly through the use of the -L switch. (Think "location".) Consequently, given the original URI, the

following command will display HTML even though the URI has no content:

```
curl -L http://dbpedia.org/resource/Walt_Disney | more
```

Now remember, the Semantic Web and linked data depend on the exchange of RDF, and upon closer examination you can see there are “link” elements in the resulting HTML, and these elements point to URLs with the .rdf extension. Feed these URLs to cURL to see an RDF representation of the Walt Disney data:

```
curl http://dbpedia.org/data/Walt_Disney.rdf | more
```

Downloading entire HTML streams, parsing them for link elements containing URLs of RDF, and then requesting the RDF is not nearly as efficient as requesting RDF from the remote server in the first place. This can be done by telling the remote server you accept RDF as a format type. This is accomplished through the use of the -H switch. (Think “header”.) For example, feed cURL the URI for Walt Disney and specify your desire for RDF/XML:

```
curl -H "Accept: application/rdf+xml" http://dbpedia.org/resource/Walt_Disney
```

Ironically, the result will be empty, and upon examination of the HTTP headers (remember the -I switch) you can see that the RDF is located at a different URL, namely, http://dbpedia.org/data/Walt_Disney.xml:

```
curl -I -H "Accept: application/rdf+xml" http://dbpedia.org/resource/Walt_Disney
```

Finally, using the -L switch, you can use the URI for Walt Disney to request the RDF directly:

```
curl -L -H "Accept: application/rdf+xml" http://dbpedia.org/resource/Walt_Disney
```

That is cURL and content-negotiation in a nutshell. A user-agent submits a URI to a remote HTTP server and specifies the type of content it desires. The HTTP server responds with URLs denoting the location of desired content. The user-agent then makes a more specific request. It is sort of like the movie. “One URI to rule them all.” In summary, remember:

- * cURL is a command-line user-agent
- * given a URL, cURL returns, by default, the body of an HTTP transaction
- * the -I switch allows you to see the HTTP header
- * the -L switch makes cURL automatically follow HTTP redirection requests
- * the -H switch allows you to specify the type of content you wish to accept
- * given a URI and the use of the -L and -H switches you are able to retrieve either HTML or RDF

Use cURL to actually see linked data in action, and here are a few more URIs to explore:

- * Walt Disney via VIAF - <http://viaf.org/viaf/36927108/>
- * origami via the Library of Congress - <http://id.loc.gov/authorities/subjects/sh85095643>
- * Paris from DBpedia - <http://dbpedia.org/resource/Paris>

10 - SPARQL tutorial

This is the simplest of SPARQL tutorials. The tutorial's purpose is two-fold: 1) through a set of examples, introduce the reader to the syntax of SPARQL queries, and 2) to enable the reader to initially explore any RDF triple store which is exposed as a SPARQL endpoint.

SPARQL (SPARQL protocol and RDF query language) is a set of commands used to search RDF triple stores. It is modeled after SQL (structured query language), the set of commands used to search relational databases. If you are familiar with SQL, then SPARQL will be familiar. If not, then think of SPARQL queries as formalized sentences used to ask a question and get back a list of answers.

Also, remember, RDF is a data structure of triples: 1) subjects, 2) predicates, and 3) objects. The subjects of the triples are always URIs -- identifiers of "things". Predicates are also URIs, but these URIs are intended to denote relationships between subjects and objects. Objects are preferably URIs but they can also be literals (words or numbers). Finally, RDF objects and predicates are defined in human-created ontologies as a set of classes and properties where classes are abstract concepts and properties are characteristics of the concepts.

Try the following steps with just about any SPARQL endpoint:

1. Get an overview - A good way to begin is to get a list of all the ontological classes in the triple store. In essence, the query below says, "Find all the unique objects in the triple store where any subject is a type of object, and sort the result by object."

```
SELECT DISTINCT ?o WHERE { ?s a ?o } ORDER BY ?o
```

2. Learn about the employed ontologies - Ideally, each of the items in the result will be an actionable URI in the form of a "cool URL". Using your Web browser, you ought to be able to go to the URL and read a thorough description of the given class, but the URLs are not always actionable.

3. Learn more about the employed ontologies - Using the following query you can create a list of all the properties in the triple store as well as infer some of the characteristics of each class. Unfortunately, this particular query is intense. It may require a long time to process or may not return at all. In English, the query says, "Find all the unique predicates where the RDF triple has any subject, any predicate, or any object, and sort the result by predicate."

```
SELECT DISTINCT ?p WHERE { ?s ?p ?o } ORDER BY ?p
```

4. Guess - Steps #2 and Step #3 are time intensive, and consequently it is sometimes easier just browse the triple store by selecting one of the "cool URLs" returned in Step #1. You can submit a modified version of Step #1's query. It says, "Find all the subjects where any RDF subject (URI) is a type of object (class)". Using the LiAM triple store, the following query tries to find all the things that are EAD finding aids.

```
SELECT ?s WHERE { ?s a <http://data.archiveshub.ac.uk/def/FindingAid> }
```

5. Learn about a specific thing - The result of Step #4 ought to be a list of (hopefully actionable) URIs. You can learn everything about that URI with the following query. It says, "Find all the predicates and objects in the triple store where the RDF triple's subject is a given value and the predicate and object are of any value, and sort the result by predicate". In this case, the given value is one of the items returned from Step #4.

```
SELECT ?p ?o WHERE { <http://infomotions.com/sandbox/liam/id/mum432> ?p ?o } ORDER BY ?p
```

6. Repeat a few times - If the results from Step #5 returned seemingly meaningful and complete information about your selected URI, then repeat Step #5 a few times to get a better feel for some of the "things" in the triple store. If the results were not meaningful, then got to Step #4 to browser another

class.

7. Take these hints - The first of these following two queries generates a list of ten URIs pointing to things that came from MARC records. The second query is used to return everything about a specific URI whose data came from a MARC record.

```
SELECT ?s WHERE { ?s a <http://simile.mit.edu/2006/01/ontologies/mods3#Record> } LIMIT 1000
SELECT ?p ?o WHERE { <http://infomotions.com/sandbox/liam/id/shumarc681792> ?p ?o } ORDER BY ?p
```

8. Read the manual - At this point, it is a good idea to go back to Step #2 and read the more formal descriptions of the underlying ontologies.

9. Browse some more - If the results of Step #3 returned successfully, then browse the objects in the triple store by selecting a predicate of interest. The following queries demonstrate how to list things like titles, creators, names, and notes.

```
SELECT ?s ?o WHERE { ?s <http://purl.org/dc/terms/title> ?o } ORDER BY ?o LIMIT 100
SELECT ?s ?o WHERE { ?s <http://simile.mit.edu/2006/01/roles#creator> ?o } ORDER BY ?o LIMIT 100
SELECT ?s ?o WHERE { ?s <http://xmlns.com/foaf/0.1/name> ?o } ORDER BY ?o LIMIT 100
SELECT ?s ?o WHERE { ?s <http://data.archiveshub.ac.uk/def/note> ?o } ORDER BY ?o LIMIT 100
```

10. Read about SPARQL - This was the tiniest of SPARQL tutorials. Using the LiAM data set as an example, it demonstrated how to do the all but simplest queries against a RDF triple store. There is a whole lot more to SPARQL than SELECT, DISTINCT, WHERE, ORDER BY, AND LIMIT commands. SPARQL supports a short-hand way of denoting classes and properties called PREFIX. It supports Boolean operations, limiting results based on "regular expressions", and a few mathematical functions. SPARQL can also be used to do inserts and deletes against the triple store. The next step is to read more about SPARQL. Consider reading the canonical documentation from the W3C, "SPARQL by example", and the Jena project's "SPARQL Tutorial". [1, 2, 3]

Finally, don't be too intimidated about SPARQL. Yes, it is possible to submit SPARQL queries by hand, but in reality, person-friendly front-ends are expected to be created making search much easier.

[1] canonical documentation - <http://www.w3.org/TR/rdf-sparql-query/>

[2] SPARQL By Example - <https://www.cambridgesemantics.com/semantic-university/sparql-by-example>

[3] SPARQL Tutorial - <http://jena.apache.org/tutorials/sparql.html>

10.1 marc2rdf.pl - make MARC records accessible via linked data

Eric Lease Morgan <eric_morgan@infomotions.com>

December 5, 2013 - first cut;

configure

```
use constant ROOT      => '/disk01/www/html/main/sandbox/liam';
use constant MARC       => ROOT . '/src/marc/';
use constant DATA     => ROOT . '/data/';
use constant PAGES     => ROOT . '/pages/';
use constant MARC2HTML => ROOT . '/etc/MARC21slim2HTML.xsl';
use constant MARC2MODS => ROOT . '/etc/MARC21slim2MODS3.xsl';
use constant MODS2RDF  => ROOT . '/etc/mods2rdf.xsl';
use constant MAXINDEX  => 100;
```

require

```
use IO::File;
use MARC::Batch;
use MARC::File::XML;
use strict;
use XML::LibXML;
use XML::LibXSLOT;
```

initialize

```
my $parser = XML::LibXML->new;
my $xslt   = XML::LibXSLOT->new;
```

process each record in the MARC directory

```
my @files = glob MARC . "*.marc";
for ( 0 .. $#files ) {
```

 # re-initialize

```
    my $marc = $files[ $_ ];
    my $handle = IO::File->new( $marc );
    binmode( STDOUT, ':utf8' );
    binmode( $handle, ':bytes' );
    my $batch = MARC::Batch->new( 'USMARC', $handle );
    $batch->warnings_off;
    $batch->strict_off;
    my $index = 0;
```

 # process each record in the batch

```
    while ( my $record = $batch->next ) {
```

 # get marcxml

```
        my $marcxml = $record->as_xml_record;
        my $_001    = $record->field( '001' )->as_string;
        $_001       =~ s/_//;
        $_001       =~ s/ +//;
        $_001       =~ s/-+//;
        print "      marc: $marc\n";
        print "  identifier: $_001\n";
        print "      URI: http://infomotions.com/sandbox/liam/id/$_001\n";
```

 # re-initialize and sanity check

```
        my $output = PAGES . "$_001.html";
```

```

if ( ! -e $output or -s $output == 0 ) {

    # transform marcxml into html
    print "          HTML: $output\n";
    my $source      = $parser->parse_string( $marcxml ) or warn $!;
    my $style       = $parser->parse_file( MARC2HTML ) or warn $!;
    my $stylesheet  = $xslt->parse_stylesheet( $style ) or warn $!;
    my $results     = $stylesheet->transform( $source ) or warn $!;
    my $html        = $stylesheet->output_string( $results );

    &save( $output, $html );

}
else { print "          HTML: skipping\n" }

# re-initialize and sanity check
my $output = DATA . "$_001.rdf";
if ( ! -e $output or -s $output == 0 ) {

    # transform marcxml into mods
    my $source      = $parser->parse_string( $marcxml ) or warn $!;
    my $style       = $parser->parse_file( MARC2MODS ) or warn $!;
    my $stylesheet  = $xslt->parse_stylesheet( $style ) or warn $!;
    my $results     = $stylesheet->transform( $source ) or warn $!;
    my $mods        = $stylesheet->output_string( $results );

    # transform mods into rdf
    print "          RDF: $output\n";
    $source         = $parser->parse_string( $mods ) or warn $!;
    my $style       = $parser->parse_file( MODS2RDF ) or warn $!;
    my $stylesheet  = $xslt->parse_stylesheet( $style ) or warn $!;
    my $results     = $stylesheet->transform( $source ) or warn $!;
    my $rdf         = $stylesheet->output_string( $results );

    &save( $output, $rdf );

}
else { print "          RDF: skipping\n" }

# prettify
print "\n";

# increment and check
$index++;
last if ( $index > MAXINDEX )

}

}

# done
exit;

sub save {

    open F, ' > ' . shift or die $!;

```

```
binmode( F, ':utf8' );  
print F shift;  
close F;  
return;
```

```
}
```

10.2 ead2rdf.pl - make EAD files accessible via linked data

Eric Lease Morgan <eric_morgan@infomotions.com>

December 6, 2013 - based on marc2linkeddata.pl

configure

use constant ROOT => '/disk01/www/html/main/sandbox/liam';

use constant EAD => ROOT . '/src/ead/';

use constant DATA => ROOT . '/data/';

use constant PAGES => ROOT . '/pages/';

use constant EAD2HTML => ROOT . '/etc/ead2html.xsl';

use constant EAD2RDF => ROOT . '/etc/ead2rdf.xsl';

use constant SAXON => 'java -jar /disk01/www/html/main/sandbox/liam/bin/saxon.jar -s:##SOURCE##
-xsl:##XSL## -o:##OUTPUT##';

require

use strict;

use XML::XPath;

use XML::LibXML;

use XML::LibXSLT;

initialize

my \$saxon = '';

my \$xsl = '';

my \$parser = XML::LibXML->new;

my \$xslt = XML::LibXSLT->new;

process each record in the EAD directory

my @files = glob EAD . "*.xml";

for (0 .. \$#files) {

re-initialize

my \$ead = \$files[\$_];

print " EAD: \$ead\n";

get the identifier

my \$xpath = XML::XPath->new(filename => \$ead);

my \$identifier = \$xpath->findvalue('/ead/eadheader/eadid');

\$identifier =~ s/[^\w]//g;

print " identifier: \$identifier\n";

print " URI: http://infomotions.com/sandbox/liam/id/\$identifier\n";

re-initialize and sanity check

my \$output = PAGES . "\$identifier.html";

if (! -e \$output or -s \$output == 0) {

transform marcxml into html

print " HTML: \$output\n";

my \$source = \$parser->parse_file(\$ead) or warn \$!;

my \$style = \$parser->parse_file(EAD2HTML) or warn \$!;

my \$stylesheet = \$xslt->parse_stylesheet(\$style) or warn \$!;

my \$results = \$stylesheet->transform(\$source) or warn \$!;

my \$html = \$stylesheet->output_string(\$results);

&save(\$output, \$html);

```

}
else { print "          HTML: skipping\n" }

# re-initialize and sanity check
my $output = DATA . "$identifier.rdf";
if ( ! -e $output or -s $output == 0 ) {

    # create saxon command, and save rdf
    print "          RDF: $output\n";
    $saxon = SAXON;
    $xsl    = EAD2RDF;
    $saxon =~ s/##SOURCE##/$ead/e;
    $saxon =~ s/##XSL##/$xsl/e;
    $saxon =~ s/##OUTPUT##/$output/e;
    system $saxon;

}
else { print "          RDF: skipping\n" }

# prettify
print "\n";

}

# done
exit;

sub save {

    open F, ' > ' . shift or die $!;
    binmode( F, ':utf8' );
    print F shift;
    close F;
    return;

}

```

10.3 store-make.pl - simply initialize an RDF triple store

```
# Eric Lease Morgan <eric_morgan@infomotions.com>
#
# December 14, 2013 - after wrestling with wilson for most of the day

# configure
use constant ETC => '/disk01/www/html/main/sandbox/liam/etc/';

# require
use strict;
use RDF::Redland;

# sanity check
my $db = $ARGV[ 0 ];
if ( ! $db ) {

    print "Usage: $0 <db>\n";
    exit;

}

# do the work; brain-dead
my $etc = ETC;
my $store = RDF::Redland::Storage->new( 'hashes', $db, "new='yes', hash-type='bdb', dir='$etc' );
die "Unable to create store ($!)" unless $store;
my $model = RDF::Redland::Model->new( $store, '' );
die "Unable to create model ($!)" unless $model;

# "save"
$store = undef;
$model = undef;

# done
exit;
```

10.4 store-add.pl - add items to an RDF triple store

```
# Eric Lease Morgan <eric_morgan@infomotions.com>
#
# December 14, 2013 - after wrestling with wilson for most of the day

# configure
use constant ETC => '/disk01/www/html/main/sandbox/liam/etc/';

# require
use strict;
use RDF::Redland;

# sanity check #1 - command line arguments
my $db = $ARGV[ 0 ];
my $file = $ARGV[ 1 ];
if ( ! $db or ! $file ) {

    print "Usage: $0 <db> <file>\n";
    exit;

}

# sanity check #2 - store exists
die "Error: po2s file not found. Make a store?\n" if ( ! -e ETC . $db . '-po2s.db' );
die "Error: so2p file not found. Make a store?\n" if ( ! -e ETC . $db . '-so2p.db' );
die "Error: sp2o file not found. Make a store?\n" if ( ! -e ETC . $db . '-sp2o.db' );

# open the store
my $etc = ETC;
my $store = RDF::Redland::Storage->new( 'hashes', $db, "new='no', hash-type='bdb', dir='$etc' " );
die "Error: Unable to open store ($!)" unless $store;
my $model = RDF::Redland::Model->new( $store, '' );
die "Error: Unable to create model ($!)" unless $model;

# sanity check #3 - file exists
die "Error: $file not found.\n" if ( ! -e $file );

# parse a file and add it to the store
my $uri = RDF::Redland::URI->new( "file:$file" );
my $parser = RDF::Redland::Parser->new( 'rdxml', 'application/rdf+xml' );
die "Error: Failed to find parser ($!)\n" if ( ! $parser );
my $stream = $parser->parse_as_stream( $uri, $uri );
my $count = 0;
while ( ! $stream->end ) {

    $model->add_statement( $stream->current );
    $count++;
    $stream->next;

}

# echo the result
warn "Namespaces:\n";
my %namespaces = $parser->namespaces_seen;
while ( my ( $prefix, $uri ) = each %namespaces ) {
```

```
warn " prefix: $prefix\n";  
warn '    uri: ' . $uri->as_string . "\n";  
warn "\n";  
  
}  
warn "Added $count statements\n";  
  
# "save"  
$store = undef;  
$model = undef;  
  
# done  
exit;
```


10.5 store-search.pl - query a triple store

Eric Lease Morgan <eric_morgan@infomotions.com>

December 14, 2013 - after wrestling with wilson for most of the day

configure

use constant ETC => '/disk01/www/html/main/sandbox/liam/etc/';

my %namespaces = (

"crm" => "http://erlangen-crm.org/current/",
"dc" => "http://purl.org/dc/elements/1.1/",
"dcterms" => "http://purl.org/dc/terms/",
"event" => "http://purl.org/NET/c4dm/event.owl#",
"foaf" => "http://xmlns.com/foaf/0.1/",
"lode" => "http://linkedevents.org/ontology/",
"lvont" => "http://lexvo.org/ontology#",
"modsrdf" => "http://simile.mit.edu/2006/01/ontologies/mods3#",
"ore" => "http://www.openarchives.org/ore/terms/",
"owl" => "http://www.w3.org/2002/07/owl#",
"rdf" => "http://www.w3.org/1999/02/22-rdf-syntax-ns#",
"rdfs" => "http://www.w3.org/2000/01/rdf-schema#",
"role" => "http://simile.mit.edu/2006/01/roles#",
"skos" => "http://www.w3.org/2004/02/skos/core#",
"time" => "http://www.w3.org/2006/time#",
"timeline" => "http://purl.org/NET/c4dm/timeline.owl#",
"wgs84_pos" => "http://www.w3.org/2003/01/geo/wgs84_pos#"

);

require

use strict;

use RDF::Redland;

sanity check #1 - command line arguments

my \$db = \$ARGV[0];

my \$query = \$ARGV[1];

if (! \$db or ! \$query) {

print "Usage: \$0 <db> <query>\n";

exit;

}

sanity check #2 - store exists

die "Error: po2s file not found. Make a store?\n" if (! -e ETC . \$db . '-po2s.db');

die "Error: so2p file not found. Make a store?\n" if (! -e ETC . \$db . '-so2p.db');

die "Error: sp2o file not found. Make a store?\n" if (! -e ETC . \$db . '-sp2o.db');

open the store

my \$etc = ETC;

my \$store = RDF::Redland::Storage->new('hashes', \$db, "new='no', hash-type='bdb', dir='\$etc');

die "Error: Unable to open store (\$!)" unless \$store;

my \$model = RDF::Redland::Model->new(\$store, '');

die "Error: Unable to create model (\$!)" unless \$model;

search

```
#my $sparql = RDF::Redland::Query->new( "CONSTRUCT { ?a ?b ?c } WHERE { ?a ?b ?c }", undef, undef,
"sparql" );
my $sparql = RDF::Redland::Query->new( "PREFIX modsrdf:
<http://simile.mit.edu/2006/01/ontologies/mods3#>\nSELECT ?a ?b ?c WHERE { ?a modsrdf:$query ?c }",
undef, undef, 'sparql' );
my $results = $model->query_execute( $sparql );
print $results->to_string;

# done
exit;
```



```

10.6 store-dump.pl - output the content of store as RDF/XML
# Eric Lease Morgan <eric_morgan@infomotions.com>
#
# December 14, 2013 - after wrestling with wilson for most of the day

# configure
use constant ETC => '/disk01/www/html/main/sandbox/liam/etc/';

# require
use strict;
use RDF::Redland;

# sanity check #1 - command line arguments
my $db = $ARGV[ 0 ];
my $uri = $ARGV[ 1 ];
if ( ! $db ) {

    print "Usage: $0 <db> <uri>\n";
    exit;

}

# sanity check #2 - store exists
die "Error: po2s file not found. Make a store?\n" if ( ! -e ETC . $db . '-po2s.db' );
die "Error: so2p file not found. Make a store?\n" if ( ! -e ETC . $db . '-so2p.db' );
die "Error: sp2o file not found. Make a store?\n" if ( ! -e ETC . $db . '-sp2o.db' );

# open the store
my $etc = ETC;
my $store = RDF::Redland::Storage->new( 'hashes', $db, "new='no', hash-type='bdb', dir='$etc' " );
die "Error: Unable to open store ($!)" unless $store;
my $model = RDF::Redland::Model->new( $store, '' );
die "Error: Unable to create model ($!)" unless $model;

# do the work
my $serializer = RDF::Redland::Serializer->new;
print $serializer->serialize_model_to_string( RDF::Redland::URI->new, $model );

# done
exit;

```

10.8 Apache2::LiAM::Dereference;

Dereference.pm - Redirect user-agents based on value of URI.

Eric Lease Morgan <eric_morgan@infomotions.com>

December 7, 2013 - first investigations; based on Apache2::Alex::Dereference

configure

use constant PAGES => 'http://infomotions.com/sandbox/liam/pages/';

use constant DATA => 'http://infomotions.com/sandbox/liam/data/';

require

use Apache2::Const -compile => qw(OK);

use CGI;

use strict;

main

sub handler {

initialize

my \$r = shift;

my \$cgi = CGI->new;

my \$id = substr(\$r->uri, length \$r->location);

wants RDF

if (\$cgi->Accept('text/html')) {

print \$cgi->header(-status => '303 See Other',

-Location => PAGES . \$id . '.html',

-Vary => 'Accept')

}

give them RDF

else {

print \$cgi->header(-status => '303 See Other',

-Location => DATA . \$id . '.rdf',

-Vary => 'Accept',

"Content-Type" => 'application/rdf+xml')

}

done

return Apache2::Const::OK;

}

1; # return true or die

11 A question from a library school student

In January of 2014 I received the following email message from a library school student. The questions they asked were apropos to the Guide, so I thought I'd include my responsegg here, but the names have been changed to protect the innocent.

From: Eric Lease Morgan <emorgan@nd.edu>

Subject: Re: RDF ontologies discussion on Code4Lib Listserv

Date: January 21, 2014 at 9:36:36 PM EST

> I'm writing you to ask you about your thoughts on implementing
> these kinds of RDF descriptions for institutional collections.
> Have you worked on a project that incorporated LD technologies
> like these descriptions? What was that experience like? Also,
> what kind of strategies have you used to implement these
> strategies, for instance, was considerable buy-in from your
> organization necessary, or were you able to spearhead it
> relatively solo? In essence, what would it "cost" to really do
> this?
>
> I apologize for the mass of questions, especially over e-mail. My
> only experience with ontology work has been theoretical, and I
> haven't met any professionals in the field yet who have actually
> used it. When I talk to my mentors about it, they are aware of it
> from an academic standpoint but are wary of it due these
> questions of cost and resource allocation, or confusion that it
> doesn't provide anything new for users. My final project was to
> build an ontology to describe some sort of resource and I settled
> on building a vocabulary to describe digital facsimiles and their
> physical artifacts, but I have yet to actually implement or use
> any of it. Nor have I had a chance yet to really use any
> preexisting vocabularies. So I've found myself in a slightly
> frustrating position where I've studied this from an academic
> perspective and seek to incorporate it in my GLAM work, but I
> lack the hands-on opportunity to play around with it.
>
> --
> MLIS Candidate

Dear MLS Candidate, no problem, really, but I don't know how much help I will really be.

The whole RDF / Semantic Web thing started more than ten years ago. The idea was to expose RDF/XML, allow robots to crawl these files, amass the data, and discover new knowledge – relationships – underneath. Many in the library profession thought this was science fiction and/or the sure pathway to professional obsolescence. Needless to say, it didn't get very far. A few years ago the idea of linked data was articulated, and in a nutshell it outlined how to make various flavors of serialized RDF available via an HTTP technique called content negotiation. This was when things like Turtle, N3, the idea of triple stores, maybe SPARQL, and other things came to fruition. This time the idea of linked data was more real and got a bit more traction, but it is still not main stream.

I have very little experience putting the idea of RDF and linked data into practice. A long time ago I created RDF versions of my Alex Catalogue and implemented a content negotiation tool against it. The Catalogue was not a part of any institution other than myself. When I saw the call for the LiAM Guidebook I applied and got the "job" because of my Alex Catalogue experiences as well as some experience with a thing colloquially called The Catholic Portal which contains content from EAD files.

I knew this previously, but linked data is all about URIs and ontologies. Minting URIs is not difficult,

but instead of rolling your own, it is better to use the URIs of others, such as the URIs in DBpedia, GeoNames, VIAF, etc. The ontologies used to create relationships between the URIs are difficult to identify, articulate, and/or use consistently. They are manifestations of human language, and human language is ambiguous. Trying to implement the nuances of human language in computer “sentences” called RDF triples is only an approximation at best. I sometimes wonder if the whole thing can really come to fruition. I look at OAI-PMH. It had the same goals, but it was finally called not a success because it was too difficult to implement. The Semantic Web may follow suit.

That said, it is not too difficult to make the metadata of just about any library or archive available as linked data. The technology is inexpensive and already there. The implementation will not necessarily implement best practices, but it will not expose incorrect nor invalid data, just data that is not the best. Assuming the library has MARC or EAD files, it is possible to use XSL to transform the metadata into RDF/XML. HTML and RDF/XML versions of the metadata can then be saved on an HTTP file system and disseminated either to humans or robots through content negotiation. Once a library or archive gets this far they can then either improve their MARC or EAD files to include more URIs, they can improve their XSLT to take better advantage of shared ontologies, and/or they can dump MARC and EAD all together and learn to expose linked data directly from (relational) databases. It is an iterative process which is never completed.

Nothing new to users? Ah, that is the rub and a sticking point with the linked data / Semantic Web thing. It is a sort of chicken & egg problem. “Show me the cool application that can be created if I expose my metadata as linked data”, say some people. On the other hand, “I can not create the cool application until there is a critical mass of available content.” Despite this issue, things are happening for readers, namely mash-ups. (I don’t like the word “users”.) Do a search in Facebook for the Athens. You will get a cool looking Web page describing Athens, who has been there, etc. This was created by assembling metadata from a host of different places (all puns intended), and one of those places were linked data repositories. Do a search in Google for the same thing. Instead of just bringing back a list of links, Google presents you with real content, again, amassed through various APIs including linked data. Visit VIAF and search for a well-known author. Navigate the result and you will maybe end up at WorldCat identities where all sorts of interesting information about an author, who they wrote with, what they wrote, and where is displayed. All of this is rooted in linked data and Web Services computing techniques. This is where the benefit comes. Library and archival metadata will become part of these mash-up – called “named graphs” – driving readers to library and archival websites. Linked data can become part of Wikipedia. It can be used to enrich descriptions of people in authority lists, gazetteers, etc.

What is the cost? Good question. Time is the biggest expense. If a person knows what they are doing, then a robust set of linked data could be exposed in less than a month, but in order to get that far many people need to contribute. Systems types to get the data out of content management systems as well as set up HTTP servers. Programmers will be needed to do the transformations. Catalogers will be needed to assist in the interpretation of AACR2 cataloging practices, etc. It will take a village to do the work, and that doesn’t even count convincing people this is a good idea.

Your frustration is not uncommon. Often times if there is not a real world problem to solve, learning anything new when it comes to computers is difficult. I took BASIC computer programming three times before anything sunk in, and it only sunk in when I needed to calculate how much money I was earning as a taxi driver.

Try implementing one of your passions. Do you collect anything? Baseball cards? Flowers? Books? Records? Music? Art? Is there something in your employer’s special collections of interest to you? Find something of interest to you. For simplicity’s sake, use a database to describe each item in the collection making sure each record in our database includes a unique key field. Identify one or more ontologies (others as well as rolling your own) whose properties match closely the names of your fields in your database. Write a program against your database to create static HTML pages. Put the pages on the Web. Write a program against your database to create static RDF/XML (or some other RDF serialization). Put the pages on the Web. Implement a content negotiation script that takes the keys to your database’s fields as input and redirects HTTP user agents to either the HTML or RDF. Submit the root of your linked data implementation to Datahub.io. Ta da! You have successfully implemented linked data and learned a whole lot along the way.

Once you get that far you can take what you have learned and apply it in a bigger and better way for a larger set of data.

On one hand the process is not difficult. It is a matter of repurposing the already existing skills of people who work in cultural heritage institutions. On the other hand, change in the ways things are done is difficult (but not as difficult in the what of what is done). The change is difficult to balance existing priorities.

Exposing library and archival content as linked data represents a different working style, but the end result is the same – making the content of our collections available for use and understanding.

HTH.

–

Eric Morgan