MAJOR PAPER

Linked Data Ontologies for Art Archives: Definitions, Examples, and Challenges

IS 438B: Archival Description and Access

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Introduction

Linked open data has become an established and yet still emerging trend in the library and information science field. The efforts to adapt collection descriptions for the Semantic Web have impacted metadata professionals' work across libraries, archives, and museum (LAM) collections, even while its wide operation is yet to be fully realized. In each of these domains, there are specific challenges and possibilities of linked open data. In the archival collection context, linked open data could allow for new routeways and exploration of finding aids and archival surrogates. Even more specifically, the adoption of linked open data in the visual art archives context gives rise to new ways of discovering digital artistic resources. However, the nature of the visual collections presents particular challenges that aren't always solved by the generally established linked open data models. As a result, new data models are developed for better, although exclusive, applications for art and rare material metadata. This "solution" may only be creating a larger problem. The proliferation of ontologies and data models may impact the overall interoperability that linked open data is trying to achieve. This paper aims to introduce and define the topic of linked open data, examine past and present projects of linked open data for visual arts archival collections, and look at the future direction of art archive description and access with linked open data as the number of ontologies continues to increase.

As Karen Gracy explains, procedures for archival description are several, diverse, and evolving. "The development of descriptive practice reveals eagerness to explore, assess, and incorporate new technologies to improve documentation, search, retrieval, and use of archival materials."[1] Linked open data is one such development, as it proposes new methods for collection description and access that drastically shift the fundamentals of common metadata procedure. Even as linked open data gains momentum, it was only recently that the established practice of locally creating and storing metadata became disavowed. Allison Mayer frames this outdated practice asserting that "a 'data silo' is a newly-pejorative term for what was once a standard: metadata sets stored locally, in isolation, usually maintained and accessed internally in a given institution."[2] In contrast, the basic principle of linked open data is just what it sounds like: providing better access to structured data by linking it with other related data on the open Semantic Web to decentralize and broaden its overall access. As an introductory note, it's important to acknowledge e a simple but noteworthy distinction; not all linked data is open, and not all open data is linked.[3] To enable linked open data, it needs to be both. It requires meaningful identifiers to be assigned to the named entities in the data that is then openly published to be referenced by others, thereby constructing an open, web-enabled information network. Setting itself apart from other descriptive practices, one of the core objectives of linked open data is to provide a web-based networked capability between related data based on meaningful links in order to promote cross-institutional interoperability and collaborative access to information.

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[1] Karen F. Gracy, "Archival Description and Linked Data: A Preliminary Study of Opportunities and Implementation Challenges," *Archival Science* 15, no. 3 (2015): http://dx.doi.org/10.1007/s10502- 014-9216-2.
[2] Allana Mayer, "Linked Open Data for Artistic and Cultural Resources," *Art Documentation: Journal of the Art Libraries Society of North America* 34 (2015): https://doi.org/10.1086/680561.
[3] Miriam Posner, "What is Linked Open Data?" Miriam Posner, January 7, 2021, video, 18:43, https://www.youtube.com/watch?v=VZBpFiLbi-Y.

What is Linked Open Data?

There are some fundamental definitions required for a basic proficiency of linked open data. As mentioned, the Semantic Web is the general and evolving infrastructure that allows for linked data. It was conceptualized and introduced by Tim Berners-Lee in 2001 as "not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation."[4] Along with Burners-Lee, it's led by the World Wide Web Consortium (W3C), who are tasked with maintaining the linked open data framework that can be utilized across applications and institutions. The meaningful links that create and build the webbed network are Uniform Resource Identifiers or URIs. Individually, a URI is "a short string that uniquely identifies a resource such as an HTML document, an image, a downloadable file, or a service."[5] Without URIs, linked data would not be possible; they are required to accurately identify and locate data. Burners-Lee emphasizes the role of URIs in his four central rules of linked data:

(1) Use URIs as names for things

(2) Use HTTP URIs so that people can look up those names

(3) When someone looks up a URI, provide useful information, using standards

(4) Include links to other URIs, so that they can discover more things.[6]

Once a URI has been assigned to a data entity, it can be linked through the Resource Description Framework (RDF), which is the standard language that structures data linkages. RDF is the glue of the linked data network or the pathways that allow for the

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[4] Tim Burners-Lee, "Linked Data – Design Issues," last modified June 18, 2009, https://www.w3.org/DesignIssues/LinkedData.html.
[5] Murtha Baca, "Glossary," In *Introduction to Metadata*, edited by Murtha Baca. 3rd ed. Los Angeles: Getty Publications, 2016. http://www.getty.edu/publications/intrometadata/glossary/.
[6] Tim Burners-Lee, "Linked Data – Design Issues," https://www.w3.org/DesignIssues/LinkedData.html.

relationships between the data. It's designed as triple statements (subject – predicate – object). To express data in triples, an ontology needs to be identified and implemented. In the context of linked data, an ontology is a conceptual model that defines the properties, relationships, functions, and constraints for a specific domain.[7] Some of the most common ontologies for the cultural heritage domain are CIDOC-CRM and the Europeana data model. The issue of the proliferation of ontologies for linked open data will be discussed in later sections. Once the RDF triples are formed and aligned with a specified ontology, the data can be serialized in a number of encoding standards, most commonly RDF/XML, JSON-LD, N-Triples, and Turtle. To retrieve linked data, the RDF-specific query language, SPARQL, is used to query and receive data. One of its distinct characteristics is that "SPARQL focuses on providing 'answers' as opposed to 'documents.' As a result, SPARQL enables deep graph searching across LOD sources and itself returns RDF data, meaning that a SPARQL query is itself a new LOD data source."[8] Defining these mechanical aspects of linked data is important to understanding the basics of how it works. However, as linked data grows and evolves, so are these technical specifications. And increasingly, metadata professionals working with art collections are developing ways to adapt general linked open data specs to their specialized collections. A number of organizations are leading the way to explore such changes, most notably, the American Art Collaborative, the Library of Congress, Europeana, and the Digital Public Library of America. In the following section, the discussion of how linked open data models and ontology specifications have been adapted and reconfigured specifically for visual art collections (CIDOC-CRM à Linked Art; BIBFRAME à ARM Ontology; Europeana à DPLA data model).

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[7] Murtha Baca, "Glossary," http://www.getty.edu/publications/intrometadata/glossary/.
[8] Erik T. Mitchell, "Library Linked Data: Research and Adoption," *Library Technology Reports* 49 (2013): 24.

Linked Open Data Projects

As the adoption of linked data capabilities becomes more widespread, there are several dominant institutions that are paving the way. Some initiatives in the LAM field have already completed the transformation of various controlled vocabularies into linked open data, including the Library of Congress Subject Headings (LCSH), Virtual International Authority File (VIAF), DBPedia, and the Getty Research Institute's major vocabulary sets—Art and Architecture Thesaurus (AAT), Thesaurus of Geographic Names (TGN), and Union List of Artist Names (ULAN). These vocabularies are now able to be used as tools for building links across the Semantic Web. They are often used with ontologies for enhanced, more authoritative descriptions for a range of materials.

A remarkable project that demonstrates the possibility of using controlled vocabularies as linked open data is the American Art Collaborative (AAC), which included the Smithsonian American Art Museum (SAAM) and thirteen other institutions. The SAAM/AAC consortium project began in 2014 to form a cooperative environment for building linked open data for American Art, experiment with reconciliation methods, and develop linked open data guidelines for the broader museum field.[9] The three main components of the project display useful ways of practicing linked data methods. First, attempting to map the data to the CIDOC conceptual reference model (CRM) ontology; second, linking the artist data together through the use of linked open data vocabularies (Getty's ULAN vocabulary, DBPedia, etc.); and third, utilizing and exploring the collections through the new linked open data model. Each of these three phases exposed various challenges, which resulted in

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[9] Craig Knoblock, et al. "Lessons Learned in Building Linked Data for the American Art Collaborative." In: *d'Amato C. et al. (eds) The Semantic Web –ISWC 2017*. Lecture Notes in Computer Science, 10588. (2017): https://doi.org/10.1007/978-3-319-68204-4_26.

particular suggestions. In particular, mapping the data from thirteen museums to the CIDOC-CRM ontology was a challenge based on the sheer amount of data to work with (which varied in its tidiness and required some data cleaning), but also because the CIDOC-CRM in itself is complicated and requires specialized knowledge. This challenge produced the need for a new target RDF model, Linked Art, which will be discussed further below. The project also found difficulty with creating links between the data with the multiple vocabularies, as the process required machine-automation to assign links followed by an extended period of human attention to verify those links. Lastly, the project needed to test for optimal ways of presenting the linked data for the user interface. By developing their browsing application, they found that exhibiting the primary entities was just as important as exhibiting the relationships among the entities. The CIDOC-CRM model was reconfigured as a simple schema on the front-end interface, and cross references between data were displayed as clear visualizations. Masking the technical complexities of the data was essential, as not to alienate the non-technical user.[10] The recommendations that resulted in this project are formed as clear, practical guidelines. They suggest, "prepare a complete set of data; relate it to an existing or emerging ontology; map it to an open, machine-readable standard, preferably RDF; link it where possible to external hubs of data; and publish."[11] Generally, the AAC project reflects Berners-Lee other set of 5-star criteria for linked open data:

(1) It's available on the web with an open license

(2) It's available as machine-readable structured data

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[10] Craig Knoblock, et al. "Lessons Learned in Building Linked Data for the American Art Collaborative." (2017): 264-276.
[11] Allana Mayer, "Linked Open Data for Artistic and Cultural Resources," (2015).

(3) It's in a non-proprietary format (e.g., CSV instead of Excel)

(4) It uses open standards from W3C (RDF and SPARQL) to identify things

(5) All the above, plus: it's linked to other people's data to provide context[12]

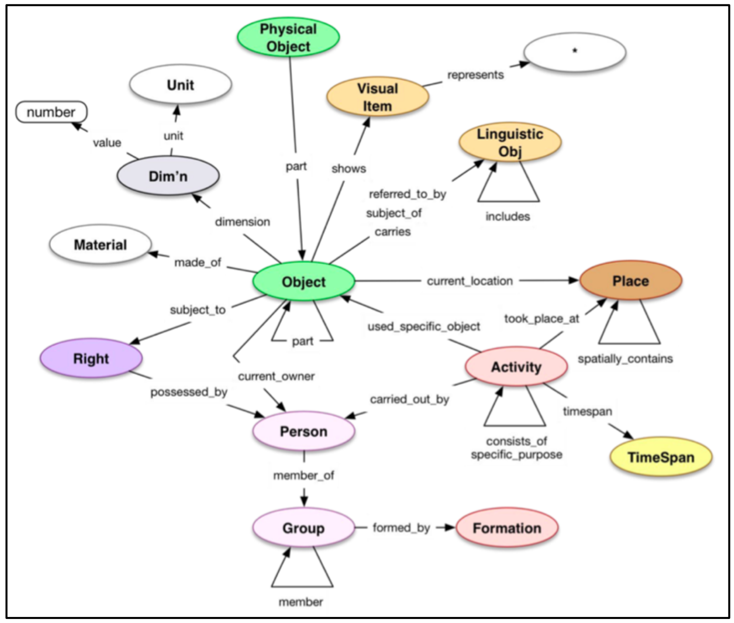

Fig. 1. Linked Art Data Model
Melissa Gill, "LAM Ontologies" class lecture, UCLA GSE&IS, Los Angeles, CA, May 11, 2020.

Not only is the AAC project an example of how established standards and guidelines can be applied, but one of the most significant aspects of the AAC initiative is the creation of the new data model, Linked Art. Eleanor Fink, the founder and manager of the AAC, explains the need for the target RDF data model was necessary based on disputes regarding how exactly to apply the CIDOC-CRM model to their specific data and the inconsistencies in their data mapping that occurred as a result. Linked Art became their suitable target model, as it presents itself as a compromise of CIDOC-CRM to promote simplified flexibility. "The AAC target model is a profile of the CRM based on the pragmatism that considers its application by multiple museums; accommodations for interoperability with other uses of RDF; can align with other Linked Data projects; and supports the existing online environment… The AAC target model is thus a balance between knowledge representation and ease of use, while it has

[12] Tim Burners-Lee, "Linked Data – Design Issues," https://www.w3.org/DesignIssues/LinkedData.html.

the flexibility to accommodate concepts and mappings beyond the target model."[13] Linked Art is founded on the CIDOC-CRM profile; however, it functions with only about 10% of the complexity of the full CRM ontology. The model enables an effective application to be built on top of the model to support varying levels of completeness and be aimed at overall usability.[14] The goal of Linked Art to be applied by multiple museums was not just achieved with the fourteen institutions with the AAC initiative, but it has since gained adoption by several other linked open data developments, such as the Getty Provenance Index, the Linked Conservation Data project (over twenty partnering institutions), the Pre-Raphaelites Art Online project, the PHAROS International Consortium of Photo Archives (fourteen partners)[15], along with several others.[16]

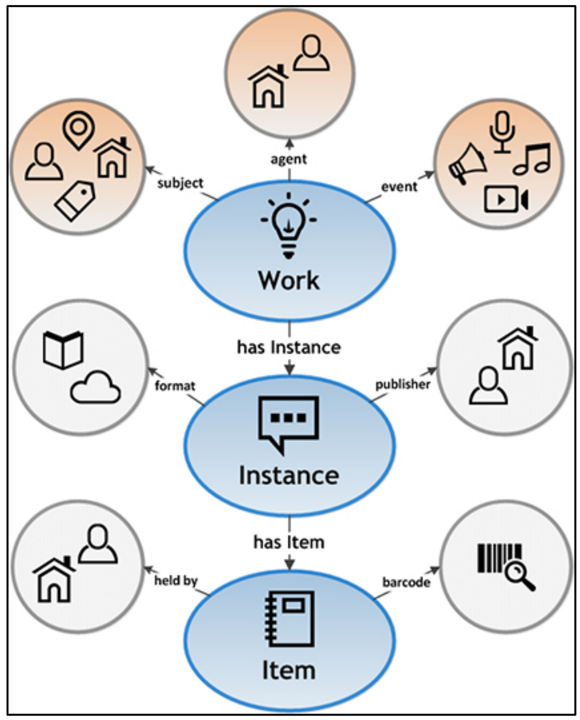

Fig. 2. BIBFRAME 2.0 Model
Library of Congress, April 21, 2016,
https://www.loc.gov/bibframe/docs/bibframe2-model.html

Across the board, BIBRAME is one of the most widely anticipated RDF linked data ontologies. It is developed by the Library of Congress and is aimed at the replacement of

[13] Eleanor Fink, "American Art Collaborative (AAC) Linked Open Data (LOD) Initiative: Overview and Recommendations for Good Practices," (2018): 35, https://s3.amazonaws.com/assets.saam.media/files/documents/2020 07/OverviewandRecommendationsAccessible.pdf.
[14] Melissa Gill, "LAM Ontologies" class lecture, UCLA GSE&IS, Los Angeles, CA, May 11, 2020.
[15] Emmanuelle Delmas-Glass and Robert Sanderson, "Fostering a Community of PHAROS Scholars through the Adoption of Open Standards," *Art Libraries Journal* 45, no. 1 (2020): 19–23. doi:10.1017/alj.2019.32.
[16] "Linked Art Community," Linked Art, accessed March 17, 2021, https://linked.art/community/index.html.

MARC metadata schema to "provide a foundation for the future of bibliographic description, both on the web, and in the broader networked world that is grounded in Linked Data techniques."[17] BIBFRAME is designed to engage with the wider information community, reaching beyond any specific domain in the library, archive, or museum field. The wide application of BIBFRAME is one of the reasons why, similar to CIDOC-CRM with Linked Art, there have been efforts to create a specific extension that's dedicated to for specialized materials. The Linked Data for Production (LD4P) initiative collaboratively develops these BIBFRAME extensions. One of the LD4P projects was Colombia University's ArtFrame project, which focused on developing an extension to BIBFRAME that would be more aligned with the needs of art catalogers. ArtFrame has since been merged with the Rare Materials Ontology to become the Art and Rare Materials BIBFRAME Ontology Extension, or ARM.[18] The ARM Ontology extension allowed the adjustments to BIBFRAME's FRBR conceptual model, which cannot be fully optimized for art and rare materials. In the FRBR model, the "work" is set at the highest-level to represent a disembodied entity, while the physical attributes are described at the lower levels. "This modelization runs counter to museum descriptive practices, in which artworks are regarded as tangible objects."[19] To solve this incongruity, the ARM Ontology created nineteen models. Some models consisting of simple revisions, while others introduce entirely new classes, properties, and relationships. For example, ARM's Marking Model is designed to properly describe an inscribed/printed/stamped/etc. symbol or notation present on a material object. The

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[17] "Bibliographic Framework Initiative," Library of Congress, accessed March 17, 2021, https://www.loc.gov/bibframe/.
[18] Elizabeth O'Keefe, Melanie Wacker, and Marie-Chantal L'Ecuyer-Coelho, "The Outcome of the ArtFrame Project: A Domain-Specific BIBFRAME Exploration," *Art Documentation: Journal of the Art Libraries Society of North America* 38, (2019): 9. doi: 10.1086/703508.
[19] Elizabeth O'Keefe, Melanie Wacker, and Marie-Chantal L'Ecuyer-Coelho, "The Outcome of the ArtFrame Project: A Domain-Specific BIBFRAME Exploration," 9.

model consists of eight unique classes (Marking, Autograph, Binder's Ticket, Inscription, Label, Seal, Stamp, and Watermark) and the two properties ('marks' and 'marked by'). In this way, the ARM Ontology addresses the limitations of BIBFRAME in regard to describing item-level characteristics. Similar to MARC, BIBFRAME only contains generic elements for describing physical details (like the 300 $b subfield or 5XX free text fields), so the multiple models of the ARM Ontology alleviate this problem for describing art and rare materials by creating more capability for granular description at the item-level.

> "Several models offer, therefore, a mechanism to identify discrete parts of a resource and describe the distinctive characteristics of each. This allows catalogers to specify, for example, that a book's text block was laser-printed on vellum paper, that its illustrations were painted in watercolors, and that its binding was made of goat suede with leather onlays. Once the information is fragmented and linked to the appropriate resource component, it becomes technically possible to build discovery systems interacting with SPARQL endpoints to enable users to search for objects based on specific criteria—e.g., to look for different examples of bindings made in a certain material or in a certain style."[20]

A key takeaway from ArtFrame project and the creation of the ARM Ontology is understanding the practical ways that linked open data relies on specialized ontologies that are in accordance with the specialized materials they are intended for. Efforts towards segmentation to achieve the appropriate amount of detail should be equated

[20] Elizabeth O'Keefe, Melanie Wacker, and Marie-Chantal L'Ecuyer-Coelho, 13.

with the details of the materials themselves. The conceptualization of the model should be consistent with the conceptualization of the object of description.

One final example of a linked open data ontology for artistic resources is the Europeana Data Model (EDM). Like CIDOC-CRM, the EDM is one of the most relevant and ambitious ontologies for connecting cultural heritage information across libraries, archives, and museums. The EDM draws from a number of existing standards, making it compatible with EAD ad METS standards, aligned with RDA content standard, and several of the EDM descriptive elements are either inspirited by or directly used from Dublin Core, CIDOC-CRM, or SKOS. However, the EDM displays some particular characteristics; for example, it "supports multiple providers describing the same object and allows for enrichment of the museum data, while clearly showing the provenance of all the data that links to digital objects."[21] Also, in contrast to CIDOC-CRM, which is event-driven, the EDM allows for both an object-centric and an event-centric approach. Its main objective is to standardize cross-cultural, multilingual data present. According to a metadata quality report from 2013-2015, Europeana aggregates metadata from over 3,000 cultural heritage institutions and performs enrichment using multilingual vocabularies such as Geonames, Dbpedia and

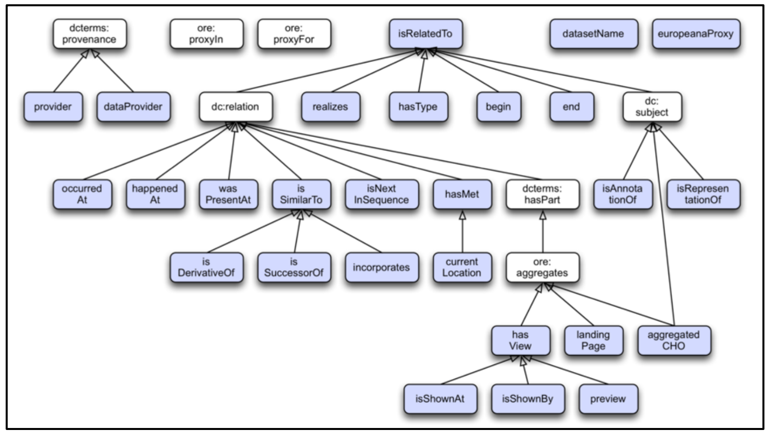

Fig. 3 Europeana Data Model
Europeana, "Definition of the Europeana Data Model v5.2.8, June 10, 2017, https://pro.europeana.eu/files/Europeana_Professional/Share_your_data/Technical_requirements/EDM_Documentation//EDM_Definition_v5.2.8_102017.pdf

[21] Victoria Boer, et. al., "Amsterdam Museum Linked Open Data," *Semantic Web* 4 (2013): 239. doi:10.3233/SW-2012-0074.

Gemet, as well as other linked open data vocabularies such as the Getty AAT, PartagePlus, Gemeinsame Normdatei (GND), IconClass, and VIAF.[22] One noteworthy adoption of the EDM is by the Amsterdam Museum.[23] The Amsterdam Museum relies on the EDM to maintain their linked open data. The museum ingests and structures their collection metadata for the EDM so that it can be published through Europeana. With cooperation with the EDM, the Amsterdam Museum is able to link to 3,753 external data sources. For scale, Victoria Boer explains, "although this is only a fraction of the total number of concepts, the usefulness of these mappings is much greater as they represent the part of the concepts with which the most metadata are annotated. In total, 70,742 out of the 73,447 (96%) objects are annotated with one or more concepts or persons that have been linked, with an average of 4.3 linked concepts per object."[24] Another effort to adopt the EDM was initiated by the Digital Public Library of America (DPLA). Like Europeana, the DPLA is an aggregator; however, the mission of the DPLA differs slightly from Europeana and certainly from the Amsterdam Museum. The DPLA aggregates metadata, not digital objects themselves, like Europeana does. Thus, the DPLA only uses a fraction of the EDM in order to represent the source content for its discovery. It is focused on linking metadata so that users can be directed to the original external repository outside of DPLA. While the purpose of EDM and DPLA are somewhat aligned as both aggregators across thousands of collections, the DPLA data model that was derived from EDM still stands as another example of a new ontology for selected use.

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[22] Marie-Claire Dangerfield, et. al., "Report and Recommendations from the Europeana Task Force on Metadata Quality," *Europeana Think Culture*, (December 2013 - May 2015): 5-20.
[23] "Amsterdam Museum in Europeana Data Model RDF," last modified December 2011, https://semanticweb.cs.vu.nl/lod/am/.
[24] Victoria Boer, et. al., "Amsterdam Museum Linked Open Data," 241.

The challenge of Increasing Ontologies

In 2017, Osma Suomine and Nina Hyvönen, both with the National Library of Finland, wrote the article, "From MARC silos to Linked Data silos?" to discuss the trajectory of linked open data across libraries, archives, and museums.[25] They review the growing trend of libraries to use different data models and argue, "The proliferation of data models limits the reusability of bibliographic data. In effect, libraries have moved from MARC silos to Linked Data silos of incompatible data models."[26] To recall Mayer's critique of data silos, this particular challenge with linked open data is especially problematic.

Through the previously discussed examples of linked data model transformations, from CIDOC-CRM to Linked Art, BIBFRAME's extension to ARM, and Europeana Data Model to DPLA's version, there is evidence to support Suomine and Hyvönen's concern. These are just examples from the arts-based description efforts, but there are more that reach beyond such domain; for example, two of the other most widely used and foundational ontologies from Schema.org and the Simple Knowledge Organization System (SKOS). Further examples are visualized in Suomine and Hyvönen's diagram of data models (fig 4). Similar to the previous discussion, the diagram looks at how the data models stem from each other as a result of prior influence and motivation to create another.

[25] Osma Suominen and Nina Hyvönen, "From MARC Silos to Linked Data Silos?" *O-Bib, Das Offene Bibliotheksjournal / Herausgeber* VDB 4, no. 2 (2017) https://doi.org/10.5282/o-bib/2017H2S1-13.
[26] Osma Suominen and Nina Hyvönen, "From MARC Silos to Linked Data Silos?" 1.

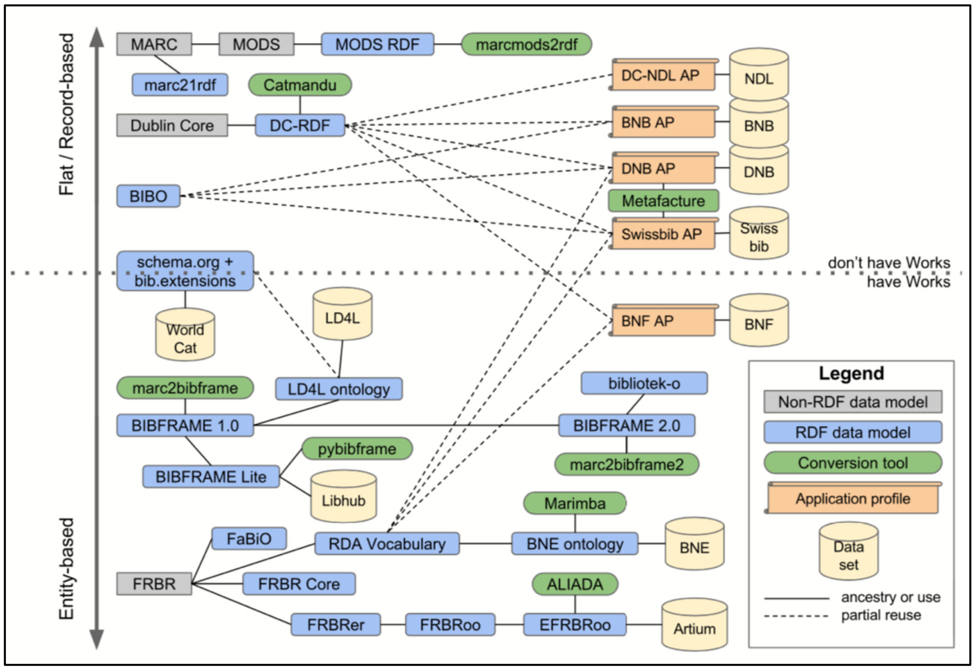

Fig. 4 "Family Forest of Bibliographic Data Models"
Suominen, Osma, and Nina Hyvönen, 2017, "From MARC Silos to Linked Data Silos?" *O-Bib, Das Offene Bibliotheksjournal / Herausgeber* VDB 4 (2):1-13, https://doi.org/10.5282/o-bib/2017H2S1-13.

In order to prevent this issue of too many data models for linked open data, Suomine and Hyvönen propose three solutions. First, try to avoid creating new data models. This recommendation likely sounds easier than it really is, as it requires varied institutions to compromise on common ground. Second, instead of developing new models, effort should be directed towards improving the already established ones. This necessitates institutions to collaborate in a much more active way. Directly working together to make localized and specialized needs known to the greater community could prevent over generalization. "It would help if the collaboration around data models was more open, transparent and organized." One practical way of achieving this is being conscientious of the tools being used to collaborate. GitHub is an example of an open platform that allows for wide input and transparent modes of communication. This was seen with the first project discussed in this paper when the

AAC developed their linked data model that would be subsequently implemented across fourteen institutions; GitHub also used among the communities working with LD4P, RDA Vocabularies, Schema.org, and many more.[27] Finally, Suomine and Hyvönen suggest the possibility of using an externally imposed data model. "a powerful external actor, such as Facebook or one of the major Web search engines, starts harvesting bibliographic data from libraries en masse." This organization would establish the exact representation that libraries would be required to use. "If the service that is based on this harvested data is attractive enough for the libraries, they would have no choice but to provide their bibliographic data using the externally imposed data model, regardless of how difficult this may be for them and how much data quality will suffer in the conversion."[28] If enacted, this final suggestion would replace the cooperative collaborations among institutions and leave little to no room for compromise. Fortunately, this situation is unlikely to occur; it is both interesting and unsettling that the authors would propose it. Giving control over to a larger dominant agent may not be in the best interest LAMs, especially when the authors frame it by saying it would be a result of the absence of choice. This would likely put specialized collections like art archives at an even greater disadvantage as they try to keep up with the more encompassing data models. The first two out of the three suggestions should be more regarded over the third one. Additionally, as demonstrated with the three project examples, the first suggestion of "avoiding new data models" may not be the most feasible. Thus, the second recommendation of improving the established models may be most beneficial for art-based archived aiming to enter the linked open data

[27] Osma Suominen and Nina Hyvönen, "From MARC Silos to Linked Data Silos?" 1.
[28] Osma Suominen and Nina Hyvönen, 12.

world, although a balance between the first and second recommendation is likely more probable.

Conclusion

The efforts towards linked open data are still shifting, adapting, and learning. While there are technical frameworks and conceptualizations in place, there are significant pathways still to be forged, especially in regard to linking artistic resources on the Semantic Web. Through the three examples of Linked Art, ARM Ontology, and DPLA, it is evident that cultural heritage materials require domain-specific provisions in the linked open data initiatives. However, we should be careful to specialize the data models so much that they aren't interoperable for the larger linked open data scheme. A balance of specialization and appropriate generalization may be most beneficial moving forward. However, most importantly, with cooperative and cross-institutional access as the primary goal of linked open data, then collaboration should also remain at the center of the developing process.

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